THE SIDEREAL MESSENGER,

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PHOTOGRAPHY AND THE INVISIBLE SOLAR PROMINENCES.

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FOR THE MESSENGER.

In 1868 a new field of investigation was opened to astronomers by the discovery of a method of observing the solar prominences in full sunshine. Hidden by the overpowering glare of the atmosphere the prominences had remained invisible except when a total eclipse allowed them to be seen rising above the limb of the moon. But in the hands of Janssen and Lockyer the great dispersion of powerful spectroscopes weakened the atmospheric spectrum until the bright prominence lines could be seen upon it, and it was then only necessary to open the slit of the spectroscope, thus bringing to view the prominences themselves. Many astronomers took up the new method of research, and countless phenomena of the greatest interest and value, became the objects of systematic investigation. In the course of time it naturally occurred to some that the prominences might be photographed, and several methods were devised for accomplishing this result. One of these is described by Dr. Braun in the "Berichten von dem Haynald-Observatorium in Kalocsa," but it required apparatus of a special nature, and has never been tried in practice. Dr. Lohse of Potsdam devoted considerable attention to the problem, and invented a "rotating spectroscope" of such ponderous proportions that mechanical difficulties alone would easily account for its failure. In 1870 Professor Young obtained photographs of two prominences through the $H\gamma$ line and a wide slit, but the evident defects of the method were visible in the pictures thus made, and nothing more was done in this direction. Thus for many years nothing was learned about the prominences by the aid of photography.

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This was the situation in the summer of 1889. The important advances accomplished by the use of photographic processes in other fields of astronomical research led me to the conclusion that another attempt should be made to photograph the prominences, and I accordingly devised two new methods for this purpose. In the first of these the image of the sun was to drift across the radial slit of a powerful spectroscope, the driving-clock of the telescope being slowed to produce the drift. It is evident that if the prominence were on the limb the length of any bright line at the focus of the spectroscope would define the height of the prominence, and as the sun drifted across the slit this line would continually change in length. If now the line in use were made to pass through a slit just within the focus of the observing telescope of the spectroscope (called hereafter the "second slit") so as to be in focus on a plate beyond the slit, it is easily seen that all that is required to photograph the prominence is to move the plate slowly at right angles to the second slit. Fresh portions of the plate are thus exposed to corresponding portions of the prominence, and the prominence image is built up from a succession of bright line images of the slit.

The second method proposed accomplishing a similar result in a different manner. The clock of the equatorial is so adjusted that the image of the sun is kept in a fixed position. The plate on the end of the collimator which carries the slit, is then slowly moved across the sun's limb at the point where the prominence is present, and a second slit, moving at the same speed before a stationary plate, excludes the light from the spectrum on either side of the line in use, and reduces fogging to a minimum.

The investigations carried on at the Harvard Observatory in 1889 and 1890, with the apparatus as originally designed, has been already described,* and need not be referred to at length here. The 18-inch silvered mirror of the horizontal telescope employed was so greatly distorted by the sun's heat that as a rule no trace of the chromosphere or prominences could be seen, and of course photography under such conditions was out of the question. It soon be-

* Technology Quarterly, Vol. III, No. 4, 1890. Astronomische Nachrichten, 3006.

came evident that an equatorial refractor of sufficient size to carry my large diffraction spectroscope was needed for the work, and instruments of the highest class became available through the kindness of Professor Holden and Professor Young, who offered the use of the 36-inch Lick telescope, and the 23-inch Princeton refractor. It was decided at this time, however, to complete the equipment of the Kenwood Physical Observatory by the addition of a 12-inch equatorial refractor built especially for spectroscopic work, and this instrument was completed and ready for use early in April of the present year. An excellent object-glass of 12.2 inches aperture was furnished by Brashear in an incredibly short time, and the very satisfactory dome and mounting were made by Warner & Swasey. The telescope and spectroscope are practically united into a single instrument, and for rigidity and convenience nothing better could be desired. The prominences are shown with the greatest perfection of detail, and the principal difficulty encountered with the horizontal telescope is thus entirely eliminated.

Meanwhile the apparatus originally designed for moving the plate at the focus of the spectroscope has undergone important modifications, and great improvements have been effected. All experiments so far made have been with the first method described above. This requires a moving plate at the focus of the spectroscope, and in the first apparatus a small plate-holder was held by a spring clip in a light frame of brass tubing sliding between V-shaped guides. After many experiments the steadiest motion that could be obtained was derived by a fine wire from the clock of the horizontal telescope, but this was very unsatisfactory, and the friction of the guides of the sliding-plate-holder made it impossible to obtain a perfectly smooth and uniform motion. In August, 1890, I planned a new form of sliding-plate-holder, in which the friction was relieved by wheels running on knife edges, a simple change giving a stationary slit and moving plate, or a moving slit and a stationary plate. But this apparatus was never constructed, for a new idea occurred to me which was carried out in an apparatus made by Mr. Brashear. In the place of a sliding-plate-holder a rotating cylinder was substituted, and around this a strip of thin celluloid photographic film is wrapped, and held by

a spring clips. The cylinder is held in a small brass box attached to the end of the observing telescope of the spectroscope, the axis of the cylinder passing through the top of the box, and carrying the pulley by which the cylinder is rotated. The bottom of the box is hinged, so that the cylinder can be removed in order to allow the second slit to be observed with a positive eye-piece passing through the back of the box. This slit can be opened or closed by turning a head at the side of the box, and by means of a slide passing before the slit the box can be closed and removed from the spectroscope without danger of exposing the film to the light.

A means of producing a slow and uniform motion is the other requisite of the method, and a modified form of clepsydra is attached to the observing telescope for this purpose. A well packed piston slides in a smoothly bored and polished brass cylinder, the piston-rod passing through stuffing boxes in each head. The cylinder is filled with a mixture of equal parts of glycerine and water, and by the motion of the piston this fluid is forced through a small brass tube connecting the two ends of the cylinder. A valve in the center of the tube regulates the rate of flow, and this is controlled by a pointer moving over a divided arc. A ten pound weight is attached to one end of the piston-rod by a flexible cord of braided wires, and the other end of the rod is connected with the pulley on the axis of the rotating film-carrier by means of a silk cord. A small "snap rubber" passes around the pulley in the opposite direction, and supplies the necessary tension. It has been found that below a certain speed the motion of the small clepsydra used cannot be relied upon as being entirely uniform, so that it is advantageous in the case of a very slow drift of the sun across the slit, to attach an arm about ten inches long in place of the pulley on the axis of the film-cylinder. The thread from the end of the piston-rod is looped over a pin on the circumference of an arc at the extremity of the arm, and as the radius of the film cylinder is only an inch, the linear velocity of a point on its surface will be only one-tenth that of the end of the arm. By means of this reduction of speed the clepsydra can run ten times as fast as when a small pulley is used, and a smooth and uniform motion is easily secured. There are some disadvantages, however, in the present form of the

valve, and some changes and further improvements will be embodied in the more convenient and practical type of apparatus now being worked out.

In my previous publications on the subject of prominence photography I have advocated the use of the C line on account of the sharp and bright images seen through it. Its position at the red end of the spectrum precludes the employment of ordinary silver bromide dry plates, and I have consequently tested a number of sensitizers for red light, but none of them have given a sufficient degree of sensitiveness. Cyanin, alizarin blue, and fresh alcoholic solutions of grass chlorophyll increase by greater or less amounts the sensitiveness of ordinary plates to red light, and are consequently very useful in some branches of spectroscopic work, but all fall short of the requirements of prominence photography. For the yellow region of the spectrum erythosin is a most valuable dye, and it is probable that prominence photographs through D_3 may be obtained by its use as a sensitizer. F has not yet been employed in this work with much success, but it is expected to prove useful. $H\gamma$ and h, though in the region where ordinary plates are most sensitive, are rarely very bright, and the nebulous character of the lines is much against them. It was through $H\gamma$, however, that my first prominence photograph was made.

But let us consider for a moment the two lines which to my mind form the most interesting group in the solar spectrum. Situated in the extreme violet the H and K lines are at about the limit of the ordinary vision. Each lies almost hidden at the center of a dark nebulous shade, within which are also included a number of other lines. Both H and K are due to calcium, and though they are probably produced at all temperatures from the Bunsen flame to the hottest star, (as I soon hope to show in a paper on this subject) they undergo great variations in intensity. Everything tends to show that calcium plays a most important part in all solar phemomena. It was found by Professor Young at Mt. Sherman in 1872 that both H and K were always bright in the chromosphere and prominences, and the same thing is shown in a large number of photographs of the chromosphere and prominence spectrum recently made here. Professor Young also observed the reversal of both lines in spots,

and in all photographs which I have made of spot spectra in this region both lines have been strongly reversed, in many cases when none of the hydrogen lines were seen bright over the spots. It is thus evident that either H or K is well suited for photographing the prominences by my method, especially as the dark shade allows the use of a wider second slit with less fogging of the plate than with any other line in the spectrum.

But most important of all is the means thus afforded of photographing prominences which cannot be seen by the spectroscopic method, and are consequently only known through photographs taken at a total eclipse. In his report of the eclipse of August 29, 1886, observed at the island of Grenada, Prof. W. H. Pickering writes as follows: "Turning now to the spectrum of the prominences, most of them showed the usual hydrogen lines, accompanied by H and K. In all cases the latter were the prominent lines, the hydrogen lines F, G, and h being decidedly weaker and less conspicuous, as is the case in the spectrum of the sun. But in the largest prominence of all—one that rose apparently in a somewhat spiral form to the altitude of 150,000 miles—the only lines visible were the H and K, and a faint trace of an ultra-violet line, about half-way between K and L. These, in addition to a brilliant continuous spectrum in the visible region, comprised the whole of its light. It was therefore quite invisible, before and after totality, by the usual spectroscopic method, as was in fact noted at the time by Professor Tacchini. It is highly probable that a great number of prominences pass by entirely unnoticed, because we rely solely upon visual instead of photographic methods of observation."*

Other observations bearing on the same point might be quoted, but the above is sufficient to show that the invisible prominences play no unimportant part among solar phenomena. Daily records are kept of the number and general forms of the spots and prominences visible on the sun, and in discussing the relation between the two, the invisible prominences are necessarily left out of account, simply because up to the present time there has been no method by

* Annals of Harvard College Observatory, Vol. XVIII, No. V, p. 99.

which they could be observed or photographed. It is evident, however, that my method takes no account of the visibility or invisibility of a prominence, but will photograph one as well as the other if either H or K is used. In fact, as H and K are so bright in the invisible prominences, they will be the easier photographed. The following record of results will show that we are now in possession of a method perfectly capable of recording the forms of any invisible prominences which may appear upon the sun.

Work on the prominences was commenced with the 12.2-inch equatorial on April 7, 1891, and the lines F and $H\gamma$ were employed, the dispersion being that of the second or third order of a 14,438 Rowland grating. Some time was occupied in adjustment of the apparatus and tests of the clepsydra, and the first photograph showing a prominence was made through the $H\gamma$ line of the second order on May 7, the sun being allowed to drift across a narrow tangential slit without employing the driving clock of the equatorial. Several more photographs were taken through the same line, but although they all showed the rough outline of the prominence, a lack of contrast made them appear very faint. It was then decided to try H and K, but a difficulty arose as to a means of bringing these faint lines on to the second slit. Induction sparks and other methods did not prove very successful and it was finally decided to use the K line in the fourth order, find its position in the green of the third order by taking $\frac{4}{3}$ its wave-length, and then bring this point in the green on to the second slit. This method proved entirely successful, and on May 14 the first attempt to photograph a prominence with the apparatus adjusted for the K gave the best result obtained up to that time. On May 18, a number of photographs of a prominence were made through the same line, the driving clock of the telescope being slowed, so that the sun drifted about $\frac{1}{8}$ inch in five minutes across a narrow tangential slit. The prominence images in some of these photographs, though of course small, show strong contrast and considerable detail, yet when compared with drawings of the same prominence made just after the exposure through the C line, the finer details of structure are missing in the photographs. If an invisible prominence had been present at this point it would certainly have been

shown, but in this case the forms through C and K were very similar. A search for invisible prominences will shortly be made and it is even hoped that they may be photographed over sun-spots or on the disk itself, though the difficulty of such work does not justify much confidence in its success.

Kenwood Physical Observatory,
Chicago, May 20, 1891.

ON THE CHIEF LINE IN THE SPECTRUM OF THE NEBULÆ

JAMES E. KEELER.*

As my paper on the Motions of the Planetary Nebulæ in the Line of Sight† did not give a final determination of the exact position of the chief nebular line, and might therefore possibly be regarded as leaving in abeyance the question as to whether that line could be regarded as a remnant of the magnesium fluting, I beg to be allowed to state briefly the results of some more recent observations, which have enabled me to fix with great accuracy the true position of the chief nebular line.

At the time when my paper on the motions of the nebulæ was printed, I had not been able to obtain any satisfactory comparisons of the third nebular line with terrestrial hydrogen, all the nebulæ in my list having proved to be too faint for the purpose. I was, therefore, compelled to adopt the mean position of the principal line for the ten nebulæ observed as the normal position from which to measure displacements, and it was for the reason that the ten nebulæ did not have the uniform distribution in the sky which was desirable that the numerical results for their motions were stated as "not to be regarded as final."

In October, 1890, when the Orion nebula came within reach of the telescope, comparisons of the third line with the $H\beta$ line of hydrogen were made without difficulty, and on

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† 'Publications of the Astronomical Society of the Pacific,' No. 11, p. 265.

the same nights the position of the principal line was determined. One such double observation, if perfect, completely solves the problem, since the displacement of the third line gives the necessary correction to the position of the first. The only question is in regard to the accuracy of the observations.

It is evident from what has already been written on this subject by Dr. and Mrs. Huggins, Professor Lockyer, and myself, that the answer to the question whether the chief nebular line is coincident with the edge of the magnesium fluting at λ 5006.4 depends upon very small differences of position, differences which would, in fact, be considered small even in solar spectroscopy. But their minuteness, although it increases the practical difficulty of observation, does not detract from their importance, since absolute coincidence of spectral lines is necessary (although not always sufficient) to establish a claim to identity of origin. It is therefore necessary to determine from a careful consideration of the Lick Observatory measures whether they are of a sufficiently high order of accuracy to prove that the small observed interval between the nebular line and the magnesium fluting is real, and not due to errors of observation.

A detailed account of all the tests to which the apparatus was subjected cannot be given here. Nothing that suggested itself was omitted. The best tests, however, both for constant and for accidental errors, are afforded by observations of the motion in the line of sight of bodies whose motion is already known. As an example of such observations, I may refer to the measures of the motion of Venus in the line of sight given in the table on p. 270, 'Publications of the Astronomical Society of the Pacific,' No. 11, in which the greatest error is one English mile per second. Similar measures of the displacement of lines in the lunar spectrum were seldom in error by more than two miles, and measures of the motion of α- Tauri and α-Orionis, usually made on the same nights that the nebula was observed, were of the same order of accuracy, as determined by their agreement with each other, and with the photographic results of Professor Vogel.

In work of this character the periodic shifting of lines in the spectra of the stars and nebulæ due to the earth's

annual motion is of a magnitude not to be neglected, and it should appear in the comparison of observations made at different seasons. So faithfully is the orbital motion of the earth reflected in my observations on the nebula of Orion, that I would with some confidence undertake to determine the month of the year, by measuring the distance of the principal line from the lead line used in the comparison spectrum.

With these remarks on the degree of accuracy which characterizes the observations, I give below the results which have been obtained, up to the present time, for the nebula of Orion.

From sixteen complete measures, made on eleven different nights (two of which were in the winter of 1889-90), the wave-length of the principal line, corrected for orbital motion of the earth, is λ 5006.22 $\pm$ 0.014, the probable error corresponding to an uncertainty of 0.5 mile per second in the line of sight. When two measures were made on the same night, they were always in different spectra of the grating.

Ten comparisons of the third nebular line with terrestrial hydrogen were made on seven nights in 1890-91, showing, when corrected for the orbital motion of the earth, a displacement of the nebular line toward the red of 0.28 $\pm$ 0.0026 tenth-metres. This corresponds to a motion of recession of the nebula from the sun of 10.7 $\pm$ 1.0 miles per second.

In recent comparisons of hydrogen with the third nebular line, I have not been able to attain the small probable error of 1½ miles per second for a single evening's comparison, given in my letter to the 'Observatory,' as the first comparisons were made under exceptionally favourable conditions. Some small improvements in the apparatus make it probable, however, that it can be reached in the future.

Examination of the individual results for each night's work shows that the errors are purely accidental; hence, the mean of the results for the third line will be used to determine a correction to the mean of the results for the first line.

A displacement of the third line toward the red of 0.28 tenth-metre corresponds to a displacement of the principal line, in the same direction, of 0.29 tenth-metre, which is the amount by which the principal line is seen to be too near the

red end of the spectrum, on account of the recession of the nebula from the sun.

Hence the wave-length of the principal line, if determined by an observer at rest relatively to the nebula, would be λ 5005.93, and this, therefore, is the *normal position* of the chief nebular line, according to all the observations of the nebula of Orion which have been made, up to the present time, at the Lick Observatory. The probable error of this result is, by the theory of least squares, 0.03 tenth-metre. The position of the MgO fluting, on the same scale, is λ 5006.36 or 0.43 tenth-metre below the normal position of the nebular line. An interval of this magnitude is not only measurable with my apparatus, but noticeable at a glance in the telescope.

An incident which occurred during the course of the work may be mentioned here, as showing how much greater the above stated interval is than any error which could be made under good conditions of observation. The measures of January 26, 1891, on being reduced the next morning, made the interval between the nebular and lead lines 0.15 tenth-metre greater than it should have been according to previous measures. This difference led me at once to infer that something was wrong with the apparatus, and on examining the instrument I found that the observing telescope was set to a reading 5° different from the usual one, in such a direction that a higher dispersion than usual had been employed. On determining the value of the micrometer for this position of the grating, and re-reducing the observations, the discrepancy was then but a few hundredths of a tenth-metre.

In the 'Journal of the British Astronomical Association,' Mr. Maunder says, in reference to the possibility of my having over-measured the interval between the chief nebular line and the edge of the magnesium fluting, "Further, some allowance must be made for the difficulty of comparing a line with a fluting; we ought certainly not to measure from the center of the nebular line to the extreme edge of the fluting. This will apply a small, but a further, correction in the same direction." Mr. Maunder's criticism does not, however, apply to my own observations, which were made with this difficulty in view. If the distance between the line and the

edge of the fluting could be measured with a slit-width vanishingly small, the true interval would be obtained. With a practicable slit-width, the position of the center of the line is unchanged, but the edge of the fluting is shifted toward the red by half the width of the line. In my observations of nebulæ, the slit-width used was such as to make the bright, sharp lead line (and hence, also, the nebular line) just the width of the coarse micrometer wire (about 0.4 tenth-metre). The bright lines were observed by occulting them with the wire, the observations thus referring to their centres, but the magnesium fluting was observed by bringing its extreme edge and the *lower* edge of the micrometer wire into coincidence, the center of the wire falling therefore upon the edge of the fluting with infinitely narrow slit. Measures of the interval between the lead line and the edge of the magnesium fluting, made with the fine micrometer wire and as narrow a slit as could be used, gave the same value as measures made in the manner just described.* The correction mentioned by Mr. Maunder is therefore unnecessary.

It appears to me, from what has been shown above, that the non-coincidence of the chief nebular line and the magnesium fluting must be regarded as proved.

In regard to the character of the line, recent observations at Mount Hamilton have shown nothing which does not confirm the opinion I have already expressed,† that under no circumstances of observation does the line tend to assume the aspect of the remnant of a fluting.

The observations which have been made at Mount Hamilton demonstrate the incorrectness of the view that the chief

* I may call attention to the fact that my own value of this interval (1.86 tenth-metres) is 0.04 tenth-metre *smaller* than the most reliable measures which have yet been published.

† "A single prism of 60° was first employed, then a compound prism of about three and one-half times the dispersion of the latter, and finally a Rowland grating of 14,438 lines to the inch. With these different degrees of dispersion, and also with other spectroscopes, employed the nebular lines appeared to be perfect monochromatic images of the slit, widening when the slit was widened and narrowing to excessively fine, sharp lines when it was closed up. The brightest line showed no tendency to assume the aspect of a 'remnant of a fluting' under any circumstances of observation."—'Publications of the Astronomical Society of the Pacific,' No. 11, p. 266 and 280.

nebular line is in any way connected with the magnesium fluting at λ 5006.36, for reasons which may be briefly summarized as follows:—

(1). The nebular line is 0.43 tenth-metre more refrangible than the lower edge of the magnesium fluting.

(2). The nebular line has no resemblance to a fluting.

(3). Flutings and lines of magnesium, which could not fail to appear at the same time with the fluting at λ 5006.36, are entirely absent in nebular spectra.

Additional reasons have been given by Professors Liveing and Dewar, and by others who have investigated the subject, but I wish to consider here only such observations as have been made at the Lick Observatory.

NEW ORIGIN FOR TERRESTRIAL LONGITUDES.

The Paris Geographical Society has recently had under consideration the fixing of a new meridian from which to reckon longitudes and set the clocks all over the earth. The matter was previously discussed by the Royal Academy of Sciences of the Bologna Institute, which admitted its inability to recommend the location of a primary meridian, but tacitly admitted that the new one now in use, passing through the Observatory at Greenwich, England, is by no means acceptable. Since then several French societies have united to recommend that the new line pass through Jerusalem and Lake Nyanza, nearly in east longitude 35 degrees according to the present method of reckoning. One reason for the selection is a long land line in the direction of the poles.

If it be admitted that a change is advisable there should be no difficulty in obtaining assent to the proposition that the most prominent geographical facts ought to govern in making the choice. The following facts may help the reader to see that the line proposed is not the best, and that another selection may be made that would be far preferable, having really overwhelming arguments in its favor.

A comparison of the numerous measures of arcs of the meridian and along parallels to the equator that have been surveyed within the last century, proves the earth to be

doubly ellipsoidal. Not only is the polar axis some twenty-six miles shorter than an equatorial diameter, but the equatorial curve itself is an ellipse, the difference between its greatest and least diameters being not far from two miles. Now, just as the equatorial line is the most natural origin for measures of latitude, so the greater and lesser meridians are the only natural lines from which to measure longitude on the earth's surface. Every other origin is open to the charge of being entirely artificial, as was the Island of Ferro with the early navigators, and as is the Greenwich Observatory now. But there are other reasons why we should select these natural meridians as the origin for measures of longitude and time reckoning, and some of them are almost entitled to be called startingly interesting.

The most complete reduction of the arc measures yet given to the world is that made by Capt. Clarke of the British Navy, who, being an Englishman, was not likely to furnish arguments in favor of unseating the Greenwich Observatory as the standard of longitude unless in obedience to the stern logic of facts. But he locates the major meridian in fifteen and a half (15°.34) degrees of east longitude. There is an uncertainty of a few minutes in the determination, so that it is not well to aim at too great precision of statement now, though it is highly desirable that the problem be again studied with the object of locating the position exactly. But as nearly as we are warranted in writing about it at present that major meridian passes one hour of longitude west of the Great Pyramid of Egypt, about which so much has been written as the earliest exponent of ancient mathematical knowledge and architectural skill that has been preserved to our day. It enters the African continent several degrees further south than does the proposed Jerusalem-Nyanza meridian, affording a magnificant land stretch from the topic of Capricorn to the Arctic circle, the only important water break in which is the Mediterranean Sea. Its extension through the poles and round the other side of the globe runs approximately through Behring Strait, and, thus divides off the American continent from the Asiatic, while it furnishes a far more natural dividing line on which the navigator of the Pacific Ocean shall change his day of reckoning than is the one now used. Then the minor meridian,

ninety degrees from the major, not only passes through the City of New York, thus distinguishing the commercial capital of this continent, but it actually runs through the Island of San Salvador, which was the first land made by Columbus when he discovered the New World four centuries ago.

With such a mass of evidence in favor of establishing the new origin of longitude on the plan above noted can there be any hesitation in pronouncing for it as against any and all others that may be advocated by scientific men who appear to have utterly ignored the greatest reasons which should govern in the selection? And if the people of the Old World cannot be brought to agree on the propriety of the plan here briefly described ought not those of the United States and of other countries on this continent to be unanimous in demanding it? Not only are the major and minor meridians of the earth the sole origins from which measures of time and longitude can legitimately be reckoned, but they offer to us the important feature of passing over the first discovered land in this hemisphere and the biggest city in it, while limiting us to the westward. It may also be mentioned that the major meridian lies almost exactly midway between the Greenwich Observatory and the earliest one we know of, as the great pyramid was undoubtedly used for purposes of astronomical observation. The matter thus briefly introduced should meet with the attention it deserves, and in that case there is no fear it will be dropped as a topic of passing interest or mere scientific curiosity.—*Chicago Tribune* April 5th, 1891.

THE SMITHSONIAN ASTRO-PHYSICAL OBSERVATORY.

The Smithsonian Institution has established as one of its departments a Physical Observatory which, with the instruments, has been supplied from the Smithsonian fund. It occupies at present a temporary structure, though funds have been subscribed for a permanent building when Congress shall provide a suitable site. For the maintenance of the Observatory an appropriation has been made by Congress which will become available on the 1st of July, 1891. The

actual instrumental work of the new Observatory will necessarily devolve largely upon a senior and a junior assistant, who have not yet been appointed, who can devote their entire time to research, and it is hoped that with the improved apparatus it will be possible to prosecute advantageously nvestigations in Telluric and Astro-physics and particularly those with the bolometer in radiant energy.

In accepting the position of Assistant Secretary of the Smithsonian Institution in 1887, Mr. Langley retained the Directorship of the Observatory at Allegheny for the purpose of completing the researches begun there, and after his appointment as Secretary of the Institution, he still continued the titular Directorship, though but a limited amount of time could be spared from his official duties at the capital. With the completion of the equipment of the little Observatory at Washington, he, however, formally resigned on April 30th, 1891, the Directorship at Allegheny which he had held since 1887, and he will, so far as his administrative occupations permit, give a personal attention to the general directions of the investigations.

The class of work which is referred to does not ordinarily involve the use of the telescope, and that which is contemplated is quite distinct from what is carried on at present at any other Observatory in the United States. The work for which the older Government Observatories at Greenwich, Paris, Berlin and Washington were founded, and in which they are now chiefly engaged, is the determination of relative positions of heavenly bodies and our own place with reference to them. Within the past twenty years all these Governments except that of the United States have established astro-physical Observatories, as they are called, which are, as is well known, engaged in the study of the heavenly bodies as distinct from their positions, in determining, for instance, not where, but what the Sun is, how it effects terrestrial climate and life, and how it may best be studied for the purposes of the meteorologist, and for other uses of an immediately practical nature.

The new Observatory is established for similar purposes. Its outfit includes a very large Siderostat (recently completed by Grubb, which is mounted in such a way as to throw a beam of light horizontally in the meridian. It is in-

tended to carry a mirror of 20 inches diameter, and is perhaps the most massive and powerful instrument of its kind ever constructed. Within the dark room is mounted another large instrument, the spectrobolometer, which is in effect a large spectroscope with 20 inch circle reading to 5 seconds of arc, specially designed for use with the bolometer. It was made by William Grunow & Son of New York, as the outcome of Mr. Langley's experience with smaller apparatus during his earlier investigations. The most important part of the instrumental equipment is completed by specially designed galvanometers, scales and a peculiar resistence box; and these three instruments used in conjunction with the bolometer, and perhaps with the aid of photography, will be employed in the investigations upon light, heat and radiant energy in general, for which the Observatory is primarily intended, though some departments of terrestrial physics may also receive attention.

THE ORBIT OF $O\Sigma$ 285.

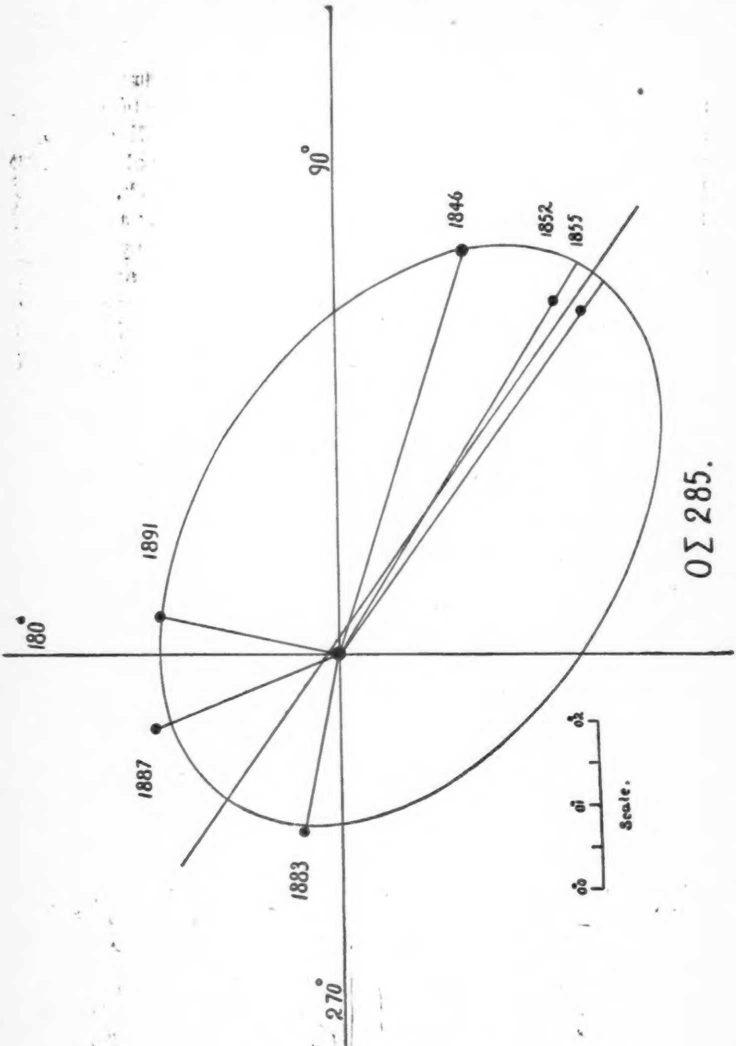
S. W. BURNHAM.

FOR THE MESSENGER.

This has always been a moderately close pair since its discovery by $O\Sigma$ more than half a century ago, and therefore but few measures have been made of it. No orbit has been computed, and indeed until recently the data has been insufficient to obtain any reliable approximate period. I have measured this pair lately with the large refractor, and with the new position there should be no difficulty in getting a provisional period, and a fairly accurate representation of the apparent orbit.

The following is a complete list of the measures to the present time.

1845.80	72.2°	0.61″	$O\Sigma$	3n
1847.96	72.2	0.42	Ma	3n
1852.69	60.6	0.45	Ma	1n
1852.74	57.8	0.50	$O\Sigma$	4n
1855.84	53.9	0.51	$O\Sigma$	3n
1857.50	65.5	0.4	Se	1n
1881.50	round or doubtful		β	
1883.84	78.3	0.22	En	5n
1887.60	202.2	0.24	Sp	4n
1891.30	168.7	0.24	β	3n



OΣ 285.

In laying down these observations, as shown on the accompanying diagram, for a graphical determination of the period, I have used a mean of the first two measures, and have rejected the single measure by Secchi in 1857, the angle of which is obviously much too large.

From this ellipse we have the following:

Period	72.7 years.
Maximum distance (1853)	0.55″
Minimum distance (1881)	0.20
Major axis (55°)	0.78
Minor axis	0.50

The distance is now increasing, and in a few years it will be comparatively easy.

This pair is never really single, and should be measurable in all parts of its orbit with a large refractor. It will be noticed that at the time I found it doubtful in 1881 the distance was minimum, and unless the occasion was very favorable, a distance of 0″.2 might be easily overlooked even with the Chicago refractor of 18½ inches. In April, 1876, I examined this with my 6-inch telescope, and noted "certainly a slight elongation in about 350°, but very close and difficult." At this time the distance must have been 0″.3, and therefore well within the reach of that instrument under suitable conditions. For some years this pair should be regularly measured. A more accurate period can then be determined, together with the other elements of the orbit.

The star is B. A. C. 4885 (= P xiv, 182), and its place (1880):

$$\text{R. A.} = 14^h\ 40^m\ 59^s$$
$$\text{Decl.} = +42°\ 53'$$

Lick Observatory, May 15.

DR. EDWARD SCHŒNFELD.*

A. KRUEGER.

On the 1st of May of the present year, after long suffering, Privy Counsellor Professor Edward Schönfeld, Director of the Bonn Observatory, died in his sixty-third year. Born at Hildburg, Dec. 22, 1828, he attended the Gymnasium of his native city and afterward the Polytechnic School at Cassel

* Translated from the German (Astronomische Nachrichten 3033) by Miss F. E. Harpham, Post-Graduate student at Carleton College.

for the study of architecture. After a year here he went to the Polytechnic school at Hanover to attend the lectures of Karmarsch, Rühlmann and Schwarz.

Here he first determined to follow his desire to study the natural sciences, and in the autumn of 1849 he went to Marburg University where, after thorough studies in chemistry, he was introduced by Gerling to the study of astronomy. In the the spring of 1852 he came to Bonn to pursue the special branch of astronomy still further. Argelander recognized at once the extraordinary talent and glowing enthusiasm of the prospective astronomer, and at Easter, 1853, when the removal of Schmidt to Olmutz left the assistant's place vacant, he bestowed it upon Schönfeld without delay, even before his promotion which took place in 1854.

Argelander was already busy in his work of mapping the northern heavens; upon Schönfeld's entry the work was hastened forward with zeal and was soon finished. During Argelander's long absence at Pulkowa, he began his first zone observations with the small comet seeker, and upon the Director's return, laid his work before him. The opportunity was given to the author of these lines to assist in this great undertaking, at first only as a volunteer but later as a constant fellow worker. The work was pushed forward steadily and successfully under the mutual emulation of the Director and his assistant.

In 1859 Schönfield was called to Mannheim as Director of the Observatory, to which place his wife, who was a true helpmate to him to the end of his life, soon followed him. In Mannheim he wished to take up work corresponding to the moderate means of the Observatory and this he accomplished successfully. The study of the variable stars, begun at Bonn was continued here and the result published in the two Mannheimer catalogues. Then with the refractor, he observed the visible nebulae of which he published an excellent catalogue. During this time the "Astronimische Gesellschaft" was founded, in the promotion of which he was of great service, especially as secretary until the year 1875.

When in 1875 the Bonn Observatory was deprived by death of the memorable Argelander, there was no question as to what astronomer should succeed him. Schönfield took the new work and, wishing to follow the traditions of the

Observatory, undertook the great work of mapping the southern sky, for which he himself made the observations and performed the greater part of the reductions. The over-exertions of these ten years laid the foundation of his later illness.

It would be an injustice to pass over in silence the service rendered by the deceased as a teacher in the university. As Privat-docent before his residence at Mannheim, he gave lectures which were distinguished by clearness of thought and profound erudition. Later, as professor of astronomy, he gave the greatest attention to this province of his work.

The wide range of Dr. Schönfeld's knowledge was surprising. He was very willing to give information and gladly conversed on topics which were beyond his own knowledge, in order to inform himself. Having a fine memory, he was extraordinarily well read and aroused the wonder of all who came into contact with him.

What his death is to his friends, the author of these lines who has been his friend more than thirty-eight years, can well estimate. He was kind and sympathetic to every one, nor did he permit any to feel his superiority. His unassuming modesty was perhaps at times too great, but for that cause no one could feel either enmity or jealousy.

Kiel, May 2, 1891.

MR. BURNHAM ON DOUBLE STARS.

GEORGE C. COMSTOCK.

FOR THE MESSENGER.

In comparing my own double-star observations with those of other observers about a year ago, I found a very persistent systematic difference between my observed position angles and Mr. Burnham's measures of the same stars. In order to obtain, if possible, an explanation of the difference between our results I asked Mr. Burnham to give me an account of his methods of observing, which he very kindly did in a letter the greater part of which is reproduced below, and which cannot fail to be of interest to every one concerned with observations of this class. It is needless to say that the letter was not written for publication. Mr. Burn-

ham has, however, consented that those parts of it which are of general interest may appear in THE MESSENGER.

It is not at all surprising that there should be difference between two observers in measuring close pairs, but there certainly should be no systematic difference in angles of either close or wide pairs, provided, of course, the proper plan is pursued in making the measures. It is absolutely necessary that the line joining the eyes should be either perpendicular or parallel to the wires. (This is true of both distances and angles.) Just how you will place the wires with reference to the stars in making angles will, of course, depend on the kind of pair you are observing, and what would be the best in one case would not be in another. A little experience will enable you to know exactly what to do in each case. In a wide pair you would ordinarily bisect the stars; with a close pair you cannot do this. In a general way, so far as I can state it, my plan is this: With one hand on the pinion and the other on the coarse screw which moves both wires, I rapidly throw the double from one side of one wire to the other, changing the angle until the wire appears to be parallel to the stars in the three positions, |: ⁑ :|. In some cases I try it also between the wires at some distance apart, that distance varying with the distance between the stars. Good measures of either distances or angles must be done quickly—that is, the motion of the wire must be rapid, and of course anything like a tangent screw and clamp is wholly unsuitable and unreliable. I don't know that now-a-days anybody uses so absurd a plan. It is far better to move the wires in position-angle by hand. In fact that is a good way, though not as convenient nor as quick. I was obliged to do this in all the measures with the Chicago micrometer. But the important thing is to have the eyes right *with reference to the object*. This is so obvious a precaution that it seems strange that any one should ever think of doing the thing in any other way, because it is in the experience of every one that it is involuntarily done under all circumstances in every day life. Let any one try to use the eyes in estimating distances, or the position of things, or to read with the head inclined 90° or wrong side up, and he will see it is the next thing to not seeing at all.

Of course in distances I always place the wires over the star. Any other plan would be but little, if any, better than an estimate, and certainly would not be measuring. I have but little faith in much that has been written about systematic errors and especially in position-angles. It is easy enough to see how one would record a transit sooner or later than another, but that has no more to do with this question than the result of throwing dice. We all go wrong, and I suppose we are never right unless by accident, but the errors in the long run should compensate each other just as much as though the angles were estimated or set down at random.

As to getting the zero of the wires, of course I let a star run along with the lowest power on. This gives it to a tenth or two, which is far nearer than anybody can measure anything with certainty and any further refinement to find the parallel would be a waste of time which would be much better spent in observing. Here, with the frequent changes in the use of the instruments I have to get the parallel almost every night.

All other sources of error in measuring double stars are insignificant when compared with that which comes from improper illumination. My measures here in 1879 with the 6-inch of the micrometer you have are of very little value from that defect. Very trifling things make the difference. Be sure you have your instrument just right, when it is right you can measure everything you can see, and with a feeling that it is fairly well done, and your results will agree with each other.

THE DIRECT ACTION OF SOLAR DISTURBANCES ON TERRESTRIAL MAGNETISM.

T. S. H. SHEARMEN.

FOR THE MESSENGER.

During the year 1882 I became convinced that there is a connection between the visibility of the sun spots *as seen from the earth* and terrestrial magnetism. At the time I was making almost daily observations of the sun, and hav- incidentally observed an aurora frequently follow the appearance of large spots at the sun's east limb, I connected the two events and concluded I had brought a new fact to light. Having secured my right to the discovery by publishing a note on the subject (unfortunately in a newspaper), I tried to interest astronomers in the matter by private correspondence. In this I failed, and I therfore determined to wait until after another spot maximum for fresh evidence before again bringing the matter up; but Professor C. A. Young having recently published an article in which he refers to this connection as having been recently discovered (or rather re-discovered) in the United States, I am compelled to again refer to my work in this connection without further delay.

This being merely a preliminary note I will give my results for three years only. They are quite sufficient though to show that there is a distinct connection between the visibility of solar disturbances from the earth and terrestrial magnetism. They show, in other words, that an active spot, or other result of a solar disturbance, when on the visible hemisphere, apparently has a greater effect on the earth's magnetism than when on the hemisphere turned away from our view. This discovery was originally made by finding on many occasions an aurora following the ap-

pearance of large spots at the sun's east limb; but I soon found that solar disturbances of every size, when first seen at that limb, apparently caused a disturbance of the earth's magnetism. To illustrate this I will give the results for the period 1885, July—1888, July. I have compared my observations of solar disturbances and auroræ during this period with the magnitude and auroral results published in the *Monthly Weather Review* of the Canadian meteorological service kindly furnished for this purpose by C. Carpmael, Esq., M. A., F. R. A. S. The accompanying table shows the result of this comparison:

Period of Observation.	No. of Disturbances at E. limb.	Coincidences with Auroræ.	Magnets more or less disturbed.	No Record. (See note.)
1885, July—1886, July....	49	29	17	3
1886, July—1887, July....	34	23	10	1
1887, July—1888, July....	26	13	11	2

NOTE.—"No record" means that the disturbance (if any) of the magnets at Toronto Observatory was not sufficient to be noticed by Mr. Carpmael in the short magnetic reviews which I consulted.

An inspection of the above table shows, I think, the connection very distinctly. It will be seen that on 65 of the 109 occasions when disturbances were at the sun's E. limb an aurora is recorded on the same date. Of the remaining occasions the magnets at the Toronto Observatory were more or less disturbed on 38 dates. This leaves only six dates to be accounted for. A closer agreement could hardly be desired—especially when we remember that many of the solar disturbances in the list were quite small.

After deducting from the list of auroræ and magnetic disturbances those caused by a solar disturbance becoming visable at the sun's E. limb, I find many remain for explanation. I will deal with these at length in a future paper, and will only say here that many disturbances of the earth's magnetism can be traced to the breaking out of spots on the sun's visible hemisphere; and to sudden changes in the activity of a disturbance already visible. I would also say here that I find faculæ can even, when without neighboring maculæ, affect the earth's magnetism. This being the case

I generally use the term *disturbance* in place of "spot." Faculæ, spots, prominences, etc., are, of course, merely the results of a solar *disturbance*. This subject will also be referred to on a future occasion.

Brantford, Canada, May 4, 1891.

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be at superior conjunction with the sun July 6 and will not be easily seen during the month of July. August 16 he will be at greatest elongation east from the sun, 27° 25′. For about a week he will be visible to the naked eye during the first hour and a half after sunset.

The transit of Mercury, on May 9, was unfortunately obscured by clouds over a large part of the United States. The only places, so far as we have heard, where good observations were obtained, were at Lick Observatory and Washington University Observatory, St. Louis, Mo. Mr. Barnard writes that he succeeded in getting both contacts at the beginning of transit. His results as to the atmospheric fringe about Mercury, both on and off the solar disk, are entirely negative. He saw no white spot upon Mercury's disk. Mr. Very, at Allegheny Observatory, observed second contact, but under very unfavorable atmospheric conditions. Mr. Comstock, at Washburn Observatory, saw the planet through clouds but lost both contacts. Mr. C. W. Pritchett, at Morrison Observatory, reports the same. At Carleton College Observatory dense clouds covered the sun until about ten minutes before sunset. We saw the planet but the images were so distorted that no fine details could be made out on the sun's surface.

Venus will be "morning star" until September, but is getting closer to the sun so it will not be observable except during the day. Venus and Neptune will be in conjunction, only 29′ apart, June 22.

Mars will be out of view for the rest of the year. *L'Astronomie* for May contains an interesting paper by C. Flammarion on observations of Mars during the past opposition. The paper reviews the observations of three Italian astronomers, Guillaume, at Peronna, Giovannozzi, at Florence, and Schiaparelli, at Milan, and is illustrated by reproductions of several drawings of the planet by these persons. They all, to a large extent, confirm the observations by Schiaparelli of the so-called "canals."

The Journal of the British Astronomical Association also contains an article by A. Stanley Williams on the same subject, reviewing observations by different observers.

Jupiter will be at quadrature with the sun June 7, rising then a little after midnight. In the morning hours before twilight good views of this planet may be obtained. His motion among the stars will be very slow during the summer, being eastward until July 7 and westward after that

time. The planet is in the constellation of Aquarius, about half way between, and a little to the east of α Pegasi (*Markab*) and α Piscis Austrinus (*Fomalhaut*). In *Monthly Notices*, April, 1891, Mr. A. Stanley Williams gives an article on the Reduction of Measures of Photographs of Jupiter taken at Lick Observatory in 1890. These photographs were enlarged directly in the telescope 8.3 times, so that the image of the planet as photographed at the time of opposition was nearly an inch in diameter. The measures of the belts and spots agree closely with visual observations made about the same time and show that photography may be made of great use in this line of work.

Saturn, although coming into unfavorable position, with reference to the sun, should be watched very closely during the summer months and all changes in the appearance of the rings, as the sunlight lowers upon them, carefully noted. During August it will be impossible to observe the planet after sunset, but good observations are possible in daylight when the altitude of the sun is low. On June 9 the sun will be 2° 13′ below the plane of the rings, while the earth will be 5° 07′ below the same plane. June 29 the same data will be respectively 1° 55′ and 4° 30′; August 8, 1° 17′ and 2° 37′; and August 28, 0° 59′ and 1° 30′. Of course one will look for this planet toward the west in the early evening.

Uranus will be in good position for observation during all of the summer months. For its position among the stars, we refer the reader to the chart of the constellation Virgo in the March number of THE MESSENGER, page 142. It will be best observed in the early evening when it is near the meridian.

Neptune is morning star but so near the rays of the sun that it will be invisible during the summer.

MERCURY.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5	6 50.4	+24 10	4 08 A. M.	11 56.8 A. M.	7 45 P. M.
15	8 21.3	+21 22	5 14 "	12 48.1 P. M.	8 22 "
25	9 35.6	+15 43	6 15 "	1 22.7 "	8 30 "
Aug. 5	10 38.5	+ 8 31	7 03 "	1 42.1 "	8 19 "
15	11 20.4	+ 2 23	7 32 "	1 44.8 "	7 58 "
25	11 45.3	− 2 07	7 35 "	1 30.3 "	7 25 "

VENUS.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5	5 30.2	+22 42	2 56 A. M.	10 36.5 A. M.	6 17 P. M.
15	6 23.1	+23 12	3 07 "	10 50.1 "	6 34 "
25	7 16.2	+22 34	3 23 "	11 03.7 "	6 44 "
Aug. 5	8 13.6	+20 27	3 48 "	11 17.7 "	6 47 "
15	9 04.5	+17 47	4 12 "	11 29.0 "	6 46 "
25	9 53.7	+14 08	4 38 "	11 38.8 "	6 40 "

MARS.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5	7 31.3	+22 51	4 56 A. M.	12 37.6 P. M.	8 19 P. M.
15	7 59.6	+21 44	4 50 "	12 25.7 "	8 02 "
25	8 25.9	+20 22	4 44 "	12 13.3 "	7 43 "
Aug. 5	8 54.8	+18 35	4 38 "	11 58.9 A. M.	7 20 "
15	9 20.1	+16 45	4 33 "	11 45.2 "	6 58 "
25	9 45.6	+14 44	4 27 "	11 30.8 "	6 34 "

JUPITER.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5	23 17.9	− 5 53	10 41 P. M.	4 21.4 A. M.	10 02 A. M.
15	23 17.5	− 5 59	10 02 "	3 41.7 "	9 22 "
25	23 16.0	− 6 12	9 22 "	3 00.8 "	8 40 "
Aug. 5	23 13.0	− 6 34	8 37 "	2 14.7 "	7 52 "
15	23 09.3	− 6 59	7 56 "	1 31.6 "	7 07 "
25	23 04.9	− 7 29	7 14 "	12 47.9 "	6 22 "

SATURN.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5	10 59.2	+ 8 36	9 27 A. M.	4 04.9 P. M.	10 42 P. M.
15	11 02.6	+ 8 14	8 53 "	3 28.8 "	10 05 "
25	11 06.1	+ 7 51	8 19 "	2 53.1 "	9 28 "
Aug. 5	11 10.6	+ 7 22	7 42 "	2 14.2 "	8 47 "
15	11 14.8	+ 6 55	7 08 "	1 39.2 "	8 10 "
25	11 19.3	+ 6 27	6 35 "	1 04.2 "	7 33 "

URANUS.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5	13 42.1	− 10 01	1 24 P. M.	6 47.2 P. M.	12 11 A. M.
15	13 42.3	− 10 02	12 44 "	6 08.0 "	11 32 P. M.
25	13 42.7	− 10 05	12 06 "	5 29.3 "	10 53 "
Aug. 5	13 43.6	− 10 11	11 24 A. M.	4 47.0 "	10 10 "
15	13 44.8	− 10 18	10 46 "	4 08.8 "	9 31 "
25	13 46.2	− 10 26	10 09 "	3 30.9 "	8 53 "

NEPTUNE.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5	4 25.4	+ 20 06	2 03 A. M.	9 32.1 A. M.	5 01 P. M
15	4 26.7	+ 20 08	1 26 "	8 54.1 "	4 22 "
25	4 27.8	+ 20 11	12 47 "	8 15.8 "	3 44 "
Aug. 5	4 28.9	+ 20 13	12 05 "	7 33.6 "	3 02 "
15	4 29.6	+ 20 14	11 26 P. M.	6 55.1 "	2 24 "
25	4 30.2	+ 20 14	10 48 "	6 16.2 "	1 45 "

THE SUN.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5	6 58.0	+ 22 47	4 22 A. M.	12 04.3 P. M.	7 47 P. M.
15	7 38.7	+ 21 30	4 30 "	12 05.7 "	7 42 "
25	8 18.9	+ 19 37	4 40 "	12 06.3 "	7 33 "
Aug. 5	9 01.8	+ 16 56	4 51 "	12 05.8 "	7 20 "
15	9 39.8	+ 14 00	5 03 "	12 04.3 "	7 06 "
25	10 16.8	+ 10 42	5 15 "	12 01.9 "	6 49 "

CERES.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
June 23	22 35.7	− 20 40	11 50 P. M.	4 27 A. M.	9 04 A. M.
July 17	22 34.4	− 22 50	10 25 "	2 51 "	7 17 "
Aug. 10	22 20.4	− 25 39	8 50 "	1 02 "	5 14 "

PALLAS.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
June 23	20 10.4	+ 19 33	6 36 P. M.	2 01 A. M.	9 26 A. M.
July 7	19 52.9	+ 18 58	4 46 "	12 09 "	7 32 "
Aug. 10	19 34.8	+ 15 58	3 08 "	10 17 "	5 26 "

JUNO.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
June 23	21 59.7	− 0 39	9 49 P. M.	3 50 A. M.	9 51 A. M.
July 17	21 57.7	− 0 48	8 14 "	2 14 "	8 14 "
Aug. 10	21 43.4	− 3 00	6 33 "	12 25 "	6 17 "

VESTA.

Date. 1891.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5	17 56.5	− 21 39	6 28 P. M.	11 00 P. M.	3 32 A. M.
29	17 41.6	− 23 21	4 47 "	9 11 "	1 35 "
Aug. 22	17 45.5	− 24 43	3 24 "	7 41 "	11 58 P. M.

Jupiter's Satellites.

		Central Time. h m		
July	3	1 06	A. M.	II Sh. In.
		3 39	"	II Tr. In.
		4 01	"	II Sh. Eg.
	4	2 48	"	I Ec. Dis.
	5	12 04	"	I Sh. In.
		1 20	"	I Tr. In.
		1 23	"	II Oc. Re.
		2 23	"	I Sh. Eg.
		3 38	"	I Tr. Eg.
		9 17	P. M.	I Ec. Dis.
	6	12 49	A. M.	I Oc. Re.
		10 06	P. M.	I Tr. Eg.
		11 04	"	IV Ec. Re.
	8	1 51	A. M.	III Sh. In.
	11	10 39	P. M.	II Ec. Dis.
		11 58	"	III Oc. Re.
	12	1 58	A. M.	I Sh. In.
		3 09	"	I Tr. In.
		3 48	"	II Oc. Re.
		11 11	P. M.	I Ec Dis.
	13	2 38	A. M.	I Oc. Re.
		9 36	P. M.	I Tr. In.
		10 11	"	II Tr. Eg.
		10 45	"	I Sh. Eg.
		11 54	"	I Tr. Eg.
	14	9 05	"	I Oc. Re..
	18	11 14	"	III Ec. Re.
	19	12 17	A. M.	III Oc. Dis.
		1 13	"	II Ec. Dis.
		3 35	"	III Oc. Re.
	20	1 06	"	I Ec. Dis.
		9 46	P. M.	II Tr. In.
		10 20	"	I Sh. In.
		10 34	"	II Sh. In.
		11 24	"	I Tr. In.
	21	12 37	A. M.	II Tr. Eg.
		12 39	"	I Sh. Eg.
		1 42	"	I Tr. Eg.
		10 53	P. M.	I Oc. Re.
	23	10 49	"	IV Oc. Dis.
	24	2 18	A. M.	IV Oc. Re.
	25	11 53	P. M.	III Ec. Dis.
	26	3 14	A. M.	III Ec. Re.
		3 48	"	II Ec. Dis.
		3 50	"	III Oc. Dis.
	27	3 00	"	I Ec. Dis.
		10 17	P. M.	II Sh. In.
	28	12 09	A. M.	II Tr. In.
		12 14	"	I Sh. In.
		1 09	"	I Tr. In.
		1 11	"	II Sh. Eg.
		2 33	"	I Sh. Eg.
		3 00	"	II Tr. Eg.
		3 27	"	I Tr. Eg.
		9 29	"	I Ec. Dis.
	29	12 40	A. M.	I Oc. Re.
		9 01	P. M.	I Sh. Eg.
July	29	9 40	P. M.	II Oc. Re.
		9 54	"	I Tr. Eg.
	31	11 39	"	IV Sh. In.
Aug.	1	3 59	A. M.	IV Sh. Eg.
	2	3 54	"	III Ec. Dis.
	4	12 55	"	II Sh. In.
		2 08	"	I Sh. In.
		2 30	"	II Tr. In.
		2 57	"	I Tr. In.
		3 49	"	II Sh. Eg.
		11 23	P. M.	I Ec. Dis.
	5	2 26	A. M.	I Oc. Re.
		7 40	P. M.	II Ec. Dis.
		8 36	"	I Sh. In.
		9 02	"	III Tr. In.
		9 23	"	I Tr. In.
		9 25	"	III Sh. Eg.
		10 55	"	I Sh. Eg.
		11 41	"	I Tr. Eg.
		11 58	"	II Oc. Re.
	6	12 21	A. M.	III Tr. Eg.
		8 53	P. M.	I Oc. Re.
	11	3 33	A. M.	II Sh. In.
		4 02	"	I Sh. In.
	12	1 18	"	I Ec. Dis.
		9 55	P. M.	III Sh. In.
		10 15	"	II Ec. Dis.
		10 30	"	I Sh. In.
		11 07	"	I Tr. In.
	13	12 26	A. M.	III Tr. In.
		12 49	"	I Sh. Eg.
		1 24	"	III Sh. Eg.
		1 25	"	I Tr. Eg.
		2 14	"	II Oc. Re.
		3 43	"	III Tr. Eg.
		7 47	"	I Ec. Dis.
		10 38	P. M.	I Oc. Re.
	14	7 18	"	I Sh. Eg.
		7 46	"	II Sh. Eg.
		7 51	"	I Tr. Eg.
		8 50	"	II Tr. Eg.
	17	10 09	"	IV Sh. Eg.
		10 43	"	IV Tr. In.
	18	2 14	A. M.	IV Tr. Eg.
	19	3 13	"	I Ec. Dis.
	20	12 24	"	I Sh. In.
		12 49	"	II Ec. Dis.
		12 51	"	I Tr. In.
		1 56	"	III Sh. In.
		2 43	"	I Sh. Eg.
		3 09	"	I Tr. Eg.
		3 45	"	III Tr. In.
		9 41	P. M.	I Ec. Dis.
	21	12 22	A. M.	I Oc. Re.
		6 53	P. M.	I Sh. In.
		7 17	"	I Tr. In.
		7 29	"	II Sh. In.

Date	Central Time. h m		Phenomenon
Aug. 21	8 17	P. M.	II Tr. In.
	9 12	"	I Sh. Eg.
	9 35	"	I Tr. Eg.
	10 22	"	II Sh. Eg.
	11 08	"	II Tr. Eg.
22	6 48	"	I Oc. Re.
23	8 37	"	III Oc. Re.
26	1 34	A. M.	IV Ec. Dis.
27	2 18	"	I Sh. In.
	2 34	"	I Tr. In.
	3 24	"	II Ec. Dis.
	11 36	P. M.	I Ec. Dis.
28	2 06	A. M.	I Oc. Re.
Aug. 28	8 47	P. M.	I Sh. In.
	9 00	"	I Tr. In.
	10 07	"	II Sh. In.
	10 33	"	II Tr. In.
	11 06	"	I Sh. Eg.
	11 18	"	I Tr. Eg.
29	1 00	A. M.	II Sh. Eg.
	1 24	"	II Tr. Eg.
	8 32	P. M.	I Oc. Re.
30	7 49	"	II Oc. Re.
	7 59	"	III Ec. Dis.
	11 53	"	III Oc. Re.

Configuration of Jupiter's Satelites at Midnight.

July 1	4 3 1 ○ 2	July 21	4 2 ○ 1 3	Aug. 11	2 1 ○ 3:4
2	4 3 ○ 2 1	22	4 3 1 ○ 2	12	♃ ○ 3 4 ●
3	4 2 3 1 ○	23	● 3 ○ 1 2	13	3 ○ 1 2 4
4	● 4 ○ 1 3	24	3 2 1 ○ 4	14	3 1 2 ○ 4
5	● 4 ○ 2 3	25	2 3 ○ 1 4	15	3 2 ○ 1 4
6	2 1 4 ○ 3	26	1 ○ 2 3 4	16	1 ○ 3 2 4
7	2 ○ 3 1 4	27	4 ○ 1 3 4	17	♃ ○ 1 2 3
8	3 1 ○ 2 4	28	● 2 ○ 3 4	18	4 2 1 ○ 3
9	3 ○ 2 1 4	29	1 3 ○ 2 4	19	4 2 ○ 1 3
10	3 2 1 ○ 4	30	3 ○ 1 2 4	20	4 3 ○ 2 ●
11	2 ○ 3 1 4	31	3 2 1 ○ 4	21	4 3 1 2 ○
12	● ○ 2 3 4	Aug. 1	4 2 3 ○ 1	22	4 3 2 ○ 1
13	2 1 ○ 3 4	2	4 1 ○ 3 2	23	4 1 ○ 3 2
14	2 ○ 1 3 4	3	4 ○ 2 1 3	24	4 ○ 1 2 3
15	3 1 4 ○ 2	4	4 2 1 ○ 3	25	2 1 4 ○ 3
16	3 4 ○ 2 1	5	♃ 4 3 ○ ●	26	2 ○ 1 3 4
17	4 3 2 1 ○	6	4 3 ○ 1 2	27	3 1 ○ 2 4
18	4 2 ○ 1 ●	7	4 3 1 2 ○	28	3 1 ○ 4 ♃
19	4 1 ○ 2 3	8	2 4 3 ○ 1	29	3 2 ○ 1 4
20	4 2 ○ 3 4	9	1 ○ 4 3 2	30	● 1 ○ 2 4
		10	○ 2143	31	○ 1234

Phases and Aspects of the Moon.

			Central Time. d	h	m	
New Moon	1891	July	5	9	58	P. M.
Apogee	"	"	11	12	24	"
First Quarter	"	"	13	11	29	"
Full Moon	"	"	21	7	54	A. M.
Perigee	"	"	23	11	00	"
Last Quarter	"	"	27	10	33	P. M.
New Moon	"	Aug.	4	11	12	A. M.
Apogee	"	"	8	4	12	"
First Quarter	"	"	12	3	12	P. M.
Full Moon	"	"	19	3	28	"
Perigee	"	"	20	2	54	"
Last Quarter	"	"	26	6	09	A. M.

Wolsingham Observatory. A new variable star was found March 2nd, at $4^h\ 26^m\ 4^s$, $+ 65° 53'$ ('55). Var. confirmed at Harvard. T. E. Espin.
Circular, No. 31.

Minima of Variable Stars of the Algol Type.

U CEPHEI.

R. A. .... $0^h\ 52^m\ 32^s$
Decl. .... $+81°\ 17'$
Period .... $2d\ 11^h\ 50^m$

July 5	2 A. M.
10	2 "
15	2 "
20	1 "
25	1 "
30	1 "
Aug. 3	midn.
8	"
13	"
18	11 P. M.
23	11 "
28	11 "

ALGOL.

R. A. .... $3^h\ 01^m\ 01^s$
Decl. .... $+40°\ 32'$
Period .... $2d\ 20^h\ 49^m$

July 11	3 A. M.
13	10 P. M.
31	3 A. M.
Aug. 2	midn.
5	8 P. M.
23	1 A. M.
25	9 P. M.

δ LIBRÆ.

R. A. .... $14^h\ 55^m\ 06^s$
Decl. .... $-8°\ 05'$
Period .... $2d\ 07^h\ 51^m$

July 13	midn.
20	"
27	"

δ LIBRÆ, Cont.

Aug. 3	11 P. M.
10	11 "
17	11 "
24	10 "
31	10 "

U CORONÆ.

R. A. .... $15^h\ 13^m\ 43^s$
Decl. .... $+32°\ 03'$
Period .... $3d\ 10^h\ 51^m$

July 7	midn.
14	10 P. M.
21	7 "
Aug. 8	2 A. M.
14	11 P. M.
21	9 "
28	7 "

U. OPHIUCHI.

R. A. .... $17^h\ 10^m\ 56^s$
Decl. .... $+1°\ 20'$
Period .... $0d\ 20^h\ 08^m$

July 3	4 A. M.
3	midn.
4	8 P. M.
9	2 A. M.
9	10 P. M.
14	2 A. M.
15	11 P. M.
19	3 A. M.
19	11 P. M.
24	midn.
25	8 P. M.
30	3 A. M.
30	11 P. M.
31	7 "
Aug. 4	2 A. M.

U. OPHIUCHI, Cont.

4	10 P. M.
9	2 A. M.
9	10 P. M.
14	3 A. M.
14	11 P. M.
19	midn.
20	8 P. M.
25	1 A. M.
25	9 P. M.
30	2 A. M.
30	10 P. M.

Y CYGNI.

R. A. .... $20^h\ 47^m\ 40^s$
Decl. .... $+34°\ 15'$
Period .... $1d\ 11^h\ 57^m$

July 4	3 A. M.
7	3 "
10	3 "
13	3 "
16	3 "
19	3 "
22	3 "
25	3 "
28	2 "
31	2 "
Aug. 3	2 "
6	2 "
9	2 "
12	2 "
15	2 "
18	2 "
21	2 "
24	2 "
27	2 "
30	1 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
July 16	κ Libræ	5.1	6 42	120	8 01.4	296	1 19
19	φ Sagittarii	3.7	11 46	126	12 46.9	226	1 01
23	τ¹ Aquarii*	5.8	9 12	57	10 11.7	263	1 00
29	ω² Tauri	5.7	14 46	123	15 20.7	187	0 35
Aug. 18	35 Capricorni	6.2	11 36	121	12 17.6	186	0 42
18	37 Capricorni	6.0	15 42	78	16 37.8	230	0 56
22	f Piscium	5.1	13 24	100	14 14.4	185	0 51
25	B. A. C. 1242	6.3	13 49	36	14 51.2	269	1 02

* Multiple Star.

COMET NOTES.

Ephemeris of the Tempel-Swift Periodic Comet. In *Bulletin Astronomique*, May, 1891, M. Bossert has published an ephemeris of this comet for the apparition of 1891. He has computed the perturbations by Jupiter and Saturn and derives the following elements for this year:

$$T = 1891, \text{ Nov. } 14.95835 \text{ Paris M. T.}$$

$$\left.\begin{aligned} \pi &= 43^\circ\ 14'\ 15.7'' \\ \Omega &= 206\ \ 31\ \ 14.8 \\ i &= 5\ \ 23\ \ 13.8 \end{aligned}\right\} 1891.0$$

$$\varphi = 40\ \ 43\ \ 44.4$$

$$\log a = 0.495370 \qquad a = 3.1288$$

$$\log q = 0.036071 \qquad q = 1.0866$$

The position of the comet in November will be very favorable for observation, as it will be almost opposite the sun at the time of its nearest approach to the earth, which will be in the latter days of November. The factor $\frac{1}{r^2\Delta^2}$ by which we judge of the brightness of the cometwas 13.17 and 6.04 in 1869 at the first and last dates of observation. In 1880 the factor was 18.46 on the first and 1.70 on the last date. This year the factor will become 1.70 on Aug. 23 and will increase to a maximum of 19.7 Nov. 26.

1891	App. R. A.	App. Decl.	log Δ (from earth)	Aberration (time)	$\frac{1}{r^2\Delta^2}$
July 2	$22^h\ 04^m\ 24^s$	$-10^\circ\ 07.5'$	0.0492	$9^m\ 18^s$	0.21
6	06 08	− 9 38.6			
10	07 28	− 9 09.8	9.9993	8 17	0.28
14	08 23	− 8 41.2			
18	08 50	− 8 12.6	9.9473	7 21	0.39
22	08 49	− 7 44.1			
26	08 15	− 7 15.7	9.8936	6 30	0.54
30	07 09	− 6 47.3			
Aug. 3	05 27	− 6 18.9	9.8390	5 44	0.74
7	03 10	− 5 50.4			
11	22 00 18	− 5 21.8	9.7845	5 03	1.04
15	21 56 52	− 4 52.9			
19	52 52	− 4 23.5	9.7314	4 28	1.44
23	48 25	− 3 53.4			
27	43 31	− 3 22.6	9.6812	3 59	1.97
31	38 20	− 2 50.9			
Sept. 4	21 33 02	− 2 18.2	9.6353	3 35	2.66
Oct. 2	21 06 24	+ 2 30.1	9.5114	2 42	6.30
Nov. 3	21 44 11	+ 13 01.6	9.3851	2 01	14.09
27	23 43 49	+ 26 24.2	9.3119	1 42	19.68
Dec. 29	3 34 45	+ 29 36.3	9.4883	2 33	6.94

The complete ephemeris for September and later months will be given in our later numbers.

The Re-Discovery of Wolf's Periodic Comet. A year ago Dr. Berberich very kindly sent me an ephemeris of Wolf's periodic comet of 1884, which he had computed in hope that I might be able to find it during 1890. I made repeated and careful searches for the comet with a 12-inch then with-

out any success, and have also searched carefully as soon as its position was favorable this year. Though the position was carefully examined the comet remained too faint to be detected until the morning of May 4th when I finally discovered it with the 12-inch close to the predicted place. Accurate filar micrometer observations gave its position.

$$1891 \text{ May } 3d\ 15^h\ 23^m\ 33^s \text{ Mt. Hamilton, M. T.}$$
$$\alpha \text{ appt.} = 22^h\ 33^m\ 16^s.71$$
$$\delta \text{ appt.} = +13^\circ\ 11'\ 27''.3$$

The comet was extremely faint and small. The estimated magnitude would be between 13.5 and 14. It was about 5″ or 10″ in diameter—a small indefinite speck of light, bright in the middle to perhaps an indefinite nucleus.

The observations that morning showed motion, so that no hesitation remained as to the identity of the object. A cipher telegram to Harvard College Observatory announcing the discovery was sent that morning at $5^h\ 45^m$. The comet has since been observed on three mornings.

In the May MESSENGER Mr. George A. Hill has given an interesting account of this comet which covers all that is known of it, except perhaps the fact that it was independently discovered on Sept. 22, 1884, by Dr. Ralph Copeland at Dun Echt, *with the spectroscope*, while searching for objects with peculiar spectra. Dr. Copeland's discovery was made before Wolf's announcement reached Dun Echt (see Dun Echt Circular, No. 89). This part of its history is important, as it is the only comet ever discovered with the spectroscope. E. E. BARNARD.

Mt. Hamilton, May 11, 1891.

Orbit and Ephemeris of Comet a 1891 (*Barnard, March 29*). From Barnard's observations of March 29 and April 3, and my own of April 8, I have computed the following elements and ephemeris:

$$T = 1891, \text{ April } 27.2156 \text{ G. M. T.}$$
$$\pi - \Omega = 175^\circ\ 8'\ 19''$$
$$\Omega = 193\ \ 43\ \ 57$$
$$i = 120\ \ 32\ \ 41$$
$$\log q = 9.61900 \qquad q = 0.41601$$

Gr. M. T.	App. R. A.	App. Dec.	Log r	Log Δ	Light.
June 1.5	4h 7m 36s	− 32° 13′	9.9743	0.0137	1.05
2.5	4 14 42	− 33 28			
3.5	4 22 5	− 34 42			
4.5	4 29 42	− 35 53			
5.5	4 37 34	− 37 3	0.0073	0.0110	0.91
6.5	4 45 41	− 38 11			
7.5	4 54 0	− 39 17			
8.5	5 2 33	− 40 20			
9.5	5 11 18	− 41 20	0.0377	0.0143	0.78
10.5	5 20 16	− 42 19			
11.5	5 29 24	− 43 14			
12.5	5 38 44	− 44 5			
13.5	5 48 13	− 44 53	0.0658	0.0238	0.66
14.5	5 57 50	− 45 38			
15.5	6 7 32	− 46 20			
16.5	6 17 19	− 46 58			

Gr. M. T.	App. R. A.	App. Dec.	Log r	Log Δ	Light.
June 17.5	6 27 7	− 47 33	0.0918	0.0386	0.54
18.5	6 37 1	− 48 4			
19.5	6 46 52	− 48 32			
20.5	5 56 37	− 48 57			
21.5	7 6 18	− 49 19	0.1160	0.0579	0.44
22.5	7 15 56	− 49 36			
23.5	7 25 26	− 49 52			
24.5	7 34 49	− 50 5			
25.5	7 44 2	− 50 15	0.1386	0.0805	0.36
26.5	7 53 6	− 50 21			
27.5	8 1 56	− 50 26			
28.5	8 10 34	− 50 29			
29.5	8 18 58	− 50 32	0.1598	0.1053	0.29
June 30.5	8 27 8	− 50 33			
July 31.5	11 6 26	− 45 25	0.2930	0.3085	0.06

An examination of the ephemeris shows that the theoretical light of the comet will be three magnitudes fainter on July 31st than at discovery. This would make the comet about 11.5 magnitude, not allowing for any intrinsic light which may have been developed. O. C. WENDELL.

Harvard College Observatory, May 13, 1891.

Observations of the Transit of Mercury.

Washington Observatory, St. Louis. These observations were made at the Observatory of Washington University, St. Louis, with the 6½ Clark Refractor, using the full aperture. A magnifying power of 140 was employed, and a shade glass was used which gave a dirty white color to the sun's disk. Although the sun had an hour angle of nearly 6 hours when the transit began the images were very steady and sharp.

Phase A, $11^h\ 53^m\ 14^s.6$, Gr. M. T.—Using a micrometer with the wire set to cut off a small segment at the exact point where the planet was expected, this was the instant when the first disturbance at the sun's edge could be detected.

Phase B, $11^h\ 55^m\ 17^s.4$, Gr. M. T.—At this instant the planet's disk was estimated to be exactly bisected by the sun's limb. This phase can be noted with great sharpness and the time given cannot be, I think, more than 4 or 5 seconds in error.

Phase C, $11^h\ 57^m\ 29^s.6$, Gr. M. T.—The planet appeared to be at this moment in geometrical contact with the sun's limb.

Phase D, $11^h\ 57^m\ 49^s.0$, Gr. M. T.—The light first flashed round the disk of the planet. Between observations (C) and (D) there was no distortion of the planet's disk but it seemed to cling to the edge of the sun. This time no doubt corresponds to the moment of true internal contact.

Observations (A) and (C) are, I think, corresponding observations of external and internal contact as affected by the irradiation. Their mean corresponds closely with (B.) H. S. PRICHETT.

May 9, 1891.

U. S. Naval Observatory. I have the honor to acknowledge the receipt of your letter of the 13th inst., respecting the late transit of Mercury, and beg you to accept my thanks for it.

Doubtless you will be interested to know that although the sun here was only about ten minutes high at the beginning of the transit, and the seeing was poor, Professor Frisby succeeded in getting very fair observations of the first and second contacts with the 9.6 in. equatorial. The resulting Greenwich mean times were:

1st contact at $11^h\ 53^m\ 49^s$
2d contact at $11\ \ 57\ \ 41$

May 18, 1891. F. V. McNair, Captain U. S. N., Supt.

The observations were made at the U. S. Naval Observatory with the 9.6 inch equatorial. The sun's image was very unsteady, but the observation of the first contact was made on the chronograph at the very first instant that anything could be seen, the second contact was the first glimpse of light that could be seen around the planet; this was also recorded on the chronograph. The times of contact are believed to be as good as the very unfavorable conditions would admit of. The magnifying power used was 132. E. Frisby.

Washburn Observatory, Madison, Wis.—Director George C. Comstock reports that "we had almost uninterrupted fair weather with beautiful 'seeing' for a fortnight, but the afternoon of the 5th, about two hours before the predicted time of the first contact for the transit of Mercury with the sun, the sky was completely overcast." No observations received.

Glasgow, Missouri.—Professor C. W. Pritchett writes: "I made very careful preparation to observe the contacts, but clouds entirely baffled me. Had the critical moments been 10^m *earlier,* or 3^m *later* I could have succeeded well. I felt much disappointed."

St. Paul, Minn.—Dr. T. D. Simonton was on the look-out for the transit. He says: "The sun was wholly invisible here at the time of contacts. At near 7 o'clock, P. M., I had a satisfactory view of Mercury crossing the sun's disc. Singularly enough at the right of Mercury was a *conspicuous round sun-spot* that might have been taken for a second (intra-Mercurial?) planet, but of double his diameter. If the atmosphere disturbances at the low altitude of the sun had not prevented my seeing the penumbra of the spot I might not have thought of such a thing."

Warner Observatory Rochester, N. Y.—Dr. Swift writes: "My observations of the transit of Mercury were rendered useless, by atmospheric tremors caused mostly by the sun being just above the roof of a building near by. The planet more nearly resembled a carrot than a disk. Two or three minutes after second contact the sun disappeared behind a large tower of the house mentioned above."

Observatory of the University of Missouri, Columbia.—Director Updegraff says: "The transit of Mercury was partially visible here through clouds. For a week preceding the transit the sky had been almost

cloudless, and the limb of the sun was plainly visible in the telescope until ten minutes before first contact. After that time clouds obscured the sun until about two minutes after the first contact. At second contact the clouds had cleared away somewhat so that I was able to observe it; but both the planet and the sun's limb were so ill-defined that the observation is not very accurate:

Second contact took place, $11^h\ 57^m\ 58^s$ G. M. T., with uncertainty of about 7^s. Physical observations were impossible on account of clouds. Instrument used was a 7½-inch equatorial.

Mr. H. C. Williams, a student, observed with a two-inch alt-azimuth telescope making second contact time, $11^h\ 57^m\ 48^s$ G. M. T.

Lyons, N. Y.—Dr. M. A. Veeder, of Lyons, N. Y., made "a satisfactory observation of the transit of Mercury with a 6-inch telescope." "The planet was seen indenting the sun's edge at $6^h\ 55^m$ and 19^s or 20^s Eastern time. The first flash of light between the planet and the sun's limb was seen at $6^h\ 58^m\ 39^s$ or 40^s. I think that the time of the second contact was very nearly correct."

Observations of the Transit of Mercury May 9, 1891, made with the 12-inch Equatorial of the Lick Observatory.—The transit of Mercury was successfully observed here on May 9 with the 12-inch equatorial.

The day proved clear throughout, though the preceding few days promised anything but a clear day for the 9th.

The first and second contacts were observed, the planet being sharply caught at the position angle predicted by Mr. Schaeberle:

1st contact 1891, May 9th, $3^h\ 46^m\ 32.7^s$, Mt. Hamilton, M. T.
2d contact 1891, May 9th, $3^h\ 51^m\ 19.9^s$, Mt. Hamilton, M. T.

I also made forty-six filar micrometer measures for the polar and equatorial diameters of Mercury, and eleven measures of the position of the planet on the sun's disk.

No trace of Mercury could be seen before first contact though it was carefully looked for, nor was that portion off the sun visible between first and second contacts. No bright spot was seen on the planet, nor any atmospheric ring—such as was seen about Venus at the transit of December 6, 1882. A careful examination of the sun's disk showed nothing that could be taken for a satellite.

Some excellent photographs of the transit were made by Mr. Burnham with the twelve inch between the micrometer measures.

As a matter of popular interest I would say that a preliminary reduction of the measures for the planet's diameter give 2960 miles for that value, which must be taken as altogether provisional, until the measures are thoroughly reduced. The measures do not indicate any polar compression.

E. E. Barnard.

Mt. Hamilton, May 11, 1891.

Note. The times of contact expressed in Standard Pacific Time (8^h slow of Greenwich) would be

1st contact, $3^h\ 53^m\ 7.0^s$.
2d contact, $3^h\ 57^m\ 54.2^s$.

The first contact occurred 1^m 11.5^s earlier than the prediction of Professor Schaebrle, which was based on the data of the American Ephemeris and Nautical Almanac; and 1^m 11^s earlier than the prediction of Professor Coakley. E. E. B.

Central High School, Philadelphia, Pa.—Under date of May 4, Professor M. B. Snyder, of the Central High School, Philadelphia, sent us the following important statement in regard to observing the transit of Mercury. We are sorry that it was not on hand earlier for the use of observers who read the MESSENGER. He says: "Calling your attention to an account of peculiar observations made on Mercury in Transit of May, '78 (see Washington Observatory, 1876, Part 2, Report of Transit of Mercury, page 100 and 101), I would ask you to see whether Mercury can not be seen as a complete disc when midway on the solar limb, using rested eyes and quick glance into the telescope. In '78 I at that phase caught a glimpse of the entire disc and very delicately illumined. Since this phenomenon has seemed to me evidence of an atmosphere of Mercury, and so far as I know the only telescopic evidence revealed by transits, I am anxious to have a careful trial made to see it again. It being possible that the phenomenon mentioned can be seen only at a certain phase of the transit it seems desirable to make repeated trials in the manner mentioned at about midway between first and second contacts.

First contact can be caught *most certainly* by the *contrast method* used by me successfully both on Mercury and Venus. Sweep telescope at the point and signal chronographically the *first peculiar change in the light tone* along the limb. Then watch and verify the appulse."

Annular Eclipse of the Sun June 6, 1891.—In our last number we gave notice of this eclipse, with chart of the path of the moon's shadow across the earth, and cut showing maximum obscuration at Northfield. For the sake of readers who may not have seen that number we repeat the substance of that note.

The central line of eclipse crosses the Arctic Ocean, touching land only in the north of Siberia. In the United States, the eclipse will be partial in the western states. At Chicago, it will last only 25 minutes, beginning at 9^h 12^m and ending at 9^h 37^m central time. At Carleton College Observatory it will begin at 8^h 45^m and end at 10^h 08^m, the moon covering only about one-eighth of the sun's diameter at the middle of eclipse. The moon will first touch the sun's limb about 55° west from the north point and leave it at 10° east from the north point. In the western part of the United States, and especially in Alaska, the obscuration will be much greater and last longer.

Brilliant Meteor. On May 3, at 9:45 P. M., Eastern standard time, a meteor appeared (as viewed from Charlottesville, Va.) near π Draconis, passed a little to the south of β Cephei, and vanished near γ Cassiopeiae, occupying about 3 seconds of time in its flight. It was many times as bright as Venus at her maximum brilliancy, and presented the appearance

of a ball from a large "Roman candle" at a distance of some 200 yds. Its light was pure white when it vanished, but during its flight there was a striking iridescence. This iridescence I cannot describe accurately, as the meteor was seen through the foliage of trees. The same cause prevented a a more accurate observation of its path. It passed behind some streaks of thin cloud, and I think the iridescence was greatest when it was shining through these. M. W. H.

University of Virginia, May 4, 1891.

A Bright Meteor. I give herewith an account of a meteor seen by myself on Sunday, May 3, at 6:13 P. M., local time; it was bright sunlight at the time. The meteor started from a point about 20° above the south-eastern horizon, pursued a northerly course, traversing an arc of about 70°, disappearing at a point about 50° above the horizon at north-east. The color was an intense white, the apparent diameter of the disc was about 10′ and there was a distinct train some six degrees in length. I could detect no report but at the point of disappearance the sky assumed a copper color for some seconds.

It was rather difficult to estimate the diameter of the meteor as it had something of the appearance of an arc light seen through ground glass. I have given what appeared to be the diameter of the nucleus.

Detroit, Mich. H. S. HULBERT.

NEWS AND NOTES.

The unusual demands on those in charge of the Observatory and THE MESSENGER during the month of May, have delayed the issue, of this number for a few days. The chief cause was the attention demanded in setting the new 16-inch telescope recently completed and now in place.

Appropriate reception exercises for the new Williams telescope, and ceremonies for naming the new Observatory building will take place June 11, 1891. This will be one of the important features of the Annual Commencement occasion at Carleton College for this year. The principal address in connection with these exercises will be delivered by Professor Charles S. Hastings, Department of Physics, Yale University. His theme will be "The History of the Telescope." A large number of invitations have been given to scientific gentlemen in the state and outside of it. The occasion promises to be one of large interest.

Mr. W. R. Warner, Warner & Swasey, Cleveland, Ohio, will be present in Northfield, during the Commencement occasion, and formally turn over the new telescope mounting to the College authorities on the part of the makers. Mr. J. A. Brashear, of Allegheny City, will also be present at the same time bringing with him the 16-inch objective and other optical parts belonging to the telescope which he is under contract to furnish. The mounting has several new features which will be described soon that our readers may know definitely of them. So far as known from preliminary

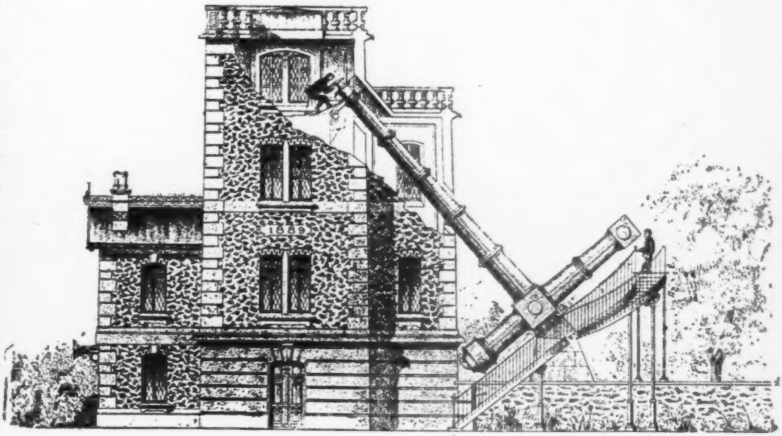
tests the objective has come out handsomely. A full report of it will also appear in due time. The rapidity with which this 16.2-inch objective has been completed is simply marvelous. The methods used in constructing this telescope and two others recently, one for E. E. Hale, of Chicago, and the other for Professor Upton, of Brown University, Providence, R. I., seem to us to promise a speedy revolution in the art and science of telescope-making.

Last month, we made a trip to Cleveland and to Pittsburgh to examine the new telescope and to give orders for details and accessories. While in Cleveland we were delightfully entertained at the home of Mr. and Mrs. W. R. Warner, who know how so well to make even informal ways contribute to a continual round of pleasure in their gifted hospitality. It was here we met Dr. Thwing, President of the University, Professor Morley and other friends including Mr. Brashear, of Pittsburgh, and Mr. and Mrs. Swasey. While in Allegheny City, to view the progress of our optical work, we found a hearty and generous welcome at the home of Mr. and Mrs. Brashear, and the day, at his shop, witnessing the tests for centering our large crown lens, and other work upon it, as well as some tests on an imperfect lens to determine causes of trouble, furnished rare opportunity for knowledge of the practical side of the optician's art. Such lessons are invaluable, no one can forget them.

Astronomical Societies. We have noticed with interest, that there is desire in the minds of those looking for means of improvement in scientific studies and general information, to form associations for this purpose. This is to be commended, and such a movement will certainly result in large profit to those who will wisely use means at hand, or that which is within easy reach. The study of elementary astronomy is no exception. It is difficult, as many an earnest student has found, to go rapidly and wisely forward, in this, or any other study, depending wholly on self-instruction. The mind should be exercised largely, liberally and sharply, in testing and using the thoughts of others on the same topics. In view of this well-known principle, we always like to give an encouraging word to those who desire to form associations for mutual aid in this respect. For amateur study, there should be at least three or four live, current publications within reach, so that students may know the drift of practical work and investigation by those who have experience. Suitable publications for this purpose are: "Publications of the Astronomical Society of the Pacific," Secretary Burckhalter, San Francisco, California; "The Journal of the British Astronomical Association," E. W. Maunder, Editor, London, England; "The Observatory," edited by H. H. Turner and A. A. Common, Royal Observatory, Greenwich, England. For knowledge and study of the professional side of the science, "The Astronomical Journal," by Dr. B. A. Gould, Cambridge, Mass., and the "Astronomische Nachrichten," by Dr. A. Krueger, Kiel, Germany, are periodicals of great value.

Another indispensible aid to the study of elementary astronomy is a telescope, large or small, according to the means of the individual or the association. The all-important question that meets the student at this point is, How can the best instrument be procured with the least outlay of money? Upon this point more will be said under another head or later.

The New Elbow Equatorial at the Observatory of Paris.—Several years ago M. Loewy devised an equatorial telescope of the "elbow" form, which would permit the observer to sit in a comfortable room, without changing position with the diurnal motion of the star in view. Such an instrument was constructed at the Observatory of Paris and has proved so satisfactory in use, that a new instrument on the same plan, considerably larger than the first, has been made and was this spring installed in its new building at Paris. The illustration which we give is reproduced from "L'Astronomie," May, 1891. The telescope is provided with both visual and photographic objectives of 0.60^m (23.6 in.) aperture, and 18 metres (59 feet) focus. The



polar axis is 18 metres long, the tube of the telescope itself forming this axis. The elbow which turns about the lower end of this axis is 4 meters long. This carries the two large plane mirrors which reflect the light of stars into the object glass. The eye-piece is at the upper end of the tube in a closed room of the tower at a height of 49 feet. An ingenious mechanism enables the telescope and mirrors to so move that the observor, without changing his position and without the discomfort of external temperature, may follow any star in its diurnal motion in any part of the visible heavens.

The new instrument, including the building in which it is placed, cost about 400,000 francs.

The image of the moon at the focus of the telescope will be 0.18^m (7.08 inches), and this will be magnified directly by the instrument so that photographs of the moon over three feet in diameter may be taken.

The Perseid Radiant. I am still unable to see any grounds for the personal quarrel which Mr. Denning seeks to fasten on me. I accept all his published observations just as Mr. Gore accepts all those of Mr. Burnham. I merely contend that these observations do not prove any shifting

of the Perseid radiant, and on this point I think any reader of the SIDEREAL MESSENGER who will examine his catalogue (striking out the word "Perseids" in his description, which in my opinion is often misapplied) will agree with me that the evidence at present available is insufficient to establish the shifting to any high degree of probability—except, perhaps for a very few days before and after August 10. This contention is based not on the rejection but on the acceptance of Mr. Denning's observations. I may illustrate it thus, Mr. Burnham contends that the observations on 61 Cygni prove nothing but rectilinear motion. I think it would be quite competent for me to contend that they establish curvilinear motion, notwithstanding that I have never measured this star myself and that my inferences might be chiefly drawn from Mr. Burnham's observations. And I am quite sure that if I did so, Mr. Burnham would reply to me in a very different tone from that adopted by Mr. Denning.

I hope the coming shower will be observed carefully in America, and I should be glad to hear the opinion of American observers—Mr. Sawyer in particular, as to the supposed shifting of the radiant.

Dublin, May 14, 1891. W. H. S. MONCK.

The Paris Observatory. The Annual Report of the Director of the Observatory of Paris for the year 1890 has recently come to hand. It gives a very full statement of the work which is being done by the different observers, and impresses one with the magnitude and variety of work which is being carried on. The principal events of 1890 to which the Director calls the attention of the Council, are the completion of the building for the new equatorial coudé of 23.6 inches aperture and the creation of a department of astronomical spectroscopy. The work in this department is put under the charge of M. Deslandres, who has already got together quite a laboratory and is adapting two instruments, the great equatorial and the Foucault siderostat, to the special work.

A considerable portion of the report is given up to a plea for the establishment of a branch Observatory outside of the city. For several years the Observatory has been becoming more and more hemmed in by the spreading city and now a railroad is run within 500 feet of the building which will render nadir observations and others, requiring perfectly stable foundation for instruments, almost impossible. The subject of the branch Observatory has been under consideration for several years and has been voted by the Council of the Observatory, and by the Academy of Sciences, but the government has not been willing to grant the necessary funds. To meet the expense of buildings the Director, Admiral Mouchez, has proposed to sell part of the vacant grounds of the Observatory which now have greatly enhanced in market value but are of no value for astronomical purposes. This has been agreed to by the Council but the Academy refuses to sanction it, and so the project has been deferred. It is to be hoped that soon some way out of the difficulty will be found, for it is a pity to have the splendid equipment of the Paris Observatory employed at a disadvantage when there are plenty of good locations near the city.

Four great national Observatories have recently found themselves in similar situations. The Observatory of Brussels has just been installed in

its new quarters at Uccle, those of Rio Janeiro, Copenhagen, and Washington are now in process of removal to new sites removed from the disturbances of the great cities.

Smithsonian Astro-Physical Observatory. Attention is called to an article elsewhere in this issue, setting forth the important fact that the Smithsonian Institution has established, as one of its departments a Physical Observatory, the object of which is to prosecute advantageously investigations in Telluric and Astro-Physics and particularly those with the Bolometer in radiant energy.

This news is gratifying in the extreme, because there is so little scientific work of this kind done anywhere in this country, and because presumably, Professor Langley will have the responsible direction of that which is now proposed at Washington, and which he is so well fitted to advance, if the needful appliances are forthcoming. It is to be hoped that the undertaking will receive hearty encouragement from every source.

New Director of Allegheny Observatory. Astronomer J. E. Keeler, of Lick Observatory, has been chosen Director of the Allegheny Observatory, to succeed Professor Langley who has recently tendered his resignation. Mr. Keeler has also been appointed Professor of Astro-Physics in the Western University of Pennsylvania located in Allegheny City, and he will assume the duties of the new position about July 1 of this year. The new buildings of the University are located very near the grounds of the Observatory and the shops of Mr. J. A. Brashear.

The Observatory at Nice.—The third volume of the Annals of the Observatory of Nice, issued in 1890, has recently been received. This is a fine quarto volume of 406 pages with also an atlas containing seventeen large steel plate engravings of the solar spectrum. The volume contains the results of observations of the solar spectrum by M. Thollon, from which the atlas was constructed, a memoir on the Theory of Vesta by M. Perrotin, meridian circle observations by MM. Fabry, Jabely, Simonin and Colomas, during the years 1887 and 1888, and observations of comets and planetoids by M. Charlois from 1886 to 1888. All of these works are of a most accurate and valuable character, but that which attracts most attention is the work of M. Thollon on the solar spectrum. The chart of the spectrum is the most accurate and, so far as it extends, most complete of any in existence which depends upon micrometric measures. The measures were made with a very powerful spectroscope designed by M. Thollon, with a train of compound prisms of bisulphide of carbon and crown glass. The chart was only completed from the extreme red region to the group (b) in the green. In this nearly half of the visible spectrum M. Thollon has designated 1100 purely *telluric* lines and 277 in which telluric lines appear to be superposed upon solar lines. It was his intention to extend the chart to the ultra-violet but illness, which resulted in his death in 1887 prevented. M. Trépied is continuing the work.

Photographic Notes.—The *Observatory* for May contains much of interest on the recent meeting in Paris of the Astrophotographic Chart Committee; below are given brief quotations from these reports of the meeting. The first resolution was that the guiding stars might be chosen at a distance up to 40′ from the centre of the field. Another point was that the plates were to be oriented for the epoch 1900 in the zones from 65° of the pole. It was arranged that the first series of plates for the chart (centres at even degrees of declination) were to be taken with a single exposure; further researches were to decide whether the committee would recommend two or three exposures instead of one for the duplicate series. Another point of importance was the selection of the reference stars in each plate, and arrangements for determining their positions; it was agreed that on each plate there should be about 6 stars the positions of which were to be well determined by meridian observations; thus it would be necessary to form a catalogue of 60,000 to 70,000 stars from meridian observations to be made within the next few years. There seemed to be a general feeling that it would be unworthy of the map if it were produced (from the negatives, by anything except photography, and that the most delicate tool—light—should replace the pantograph.

The method proposed by Captain Abney for determining stellar magnitudes photographically is worthy of careful attention. He measures the total obstruction to light offered by the image when it is placed as a screen in front of an aperture. It can in this way be compared with a scale of screens or with a graduated screen and the total action measured; the relation between the total action and the brightness of the source has been specially and successfully investigated by Captain Abney.

Mr. Roberts speaks strongly of the uncertainties which are met in determining lengths of exposure in stellar photography. He mentions extraordinary differences in results on different nights, having found in one case that an hour's exposure on a seemingly good night photographed less stars than a fifteen minute exposure on an apparently bad night.

In regard to preliminary exposures Captain Abney recently said: "I think it would be very much better to get a more sensitive plate which does not require a preliminary exposure. As a rule I believe that every quick plate that is sold has had a preliminary exposure, or what is equivalent, a preliminary decomposition of silver salts, that is to say that the manufacturer has fogged it unwittingly. A plate 15 on the sensitometer may be made to show 23 by a preliminary exposure. When you come to estimate star magnitudes you must recollect you are altering entirely the ratio of your densities and discs when you give this preliminary exposure. * * * If you want to get out a great many stars and do not care about their magnitudes particularly it would be very advisible to give a preliminary exposure, but if you wish to measure magnitudes do not do it. It is better to have a standard, and the only standard is a plate that is perfectly bright."

It is stated that the first photograph of lightning was taken by Mr. Hestler, of Chicago, in 1856, when he obtained a daguerreotype of a flash of lightning which was of excellent quality.

Boston University Observatory for Instruction.—Boston University has recently added to its facilities for instruction, by the erection of a small Astronomical Observatory. The telescope has an object glass of seven inches clear aperture, with a focal length of eight feet and one inch.

The lenses were ground by John Clacey, of Boston, and are finely corrected. The equatorial mounting, driving clock and filar micrometer were made by G. W. Saegmuller, of Washington. A Bond sidereal chronometer furnishes the time; it is being rated by comparison with a sounder placed in the Observatory, and, through the courtesy of Director E. C. Pickering, connected with the Cambridge time service.

The dome was erected by N. M. Lowe, of Boston. It is twelve feet in diameter, formed of oak ribs covered with copper, and revolves with greatest ease upon wheels in a "live ring." The shutter, two and one-half feet wide, is believed to be, in some respects, unique in its mechanical arrangement. It moves to one side by means of a crank and endless chain with rack and pinion. This movement leaves practically the entire slit free, and in every position the shutter fits closely to the dome, thus offering no objectionable surface to the wind.

The provisional position of the telescope is $\varphi = 42° 21' 32.5''$, $\lambda = 4^h 44^m 15^s$. The instrument is designed primarily for purposes of instruction, though such work will be undertaken as the location of the instrument and the duties of the lecture room will permit.

Defects of Sensitive Levels.—Professor Safford's interesting article upon meridian observations, contained in the last number of the MESSENGER calls attention to a defect in the spirit levels which is too rarely taken into account by observers in this country: "In some cases impurities in the ether dissolve particles of the glass, loosen other particles, and they make the bubble sluggish by adhesion." It is interesting to note that this peculiarity of levels has been made the subject of special study by one of the scientific bureaux of the German government and the results attained are briefly summarized in a communication recently submitted to the Reichstag.* The following is a rather free translation of that part of the report which has reference to this matter:

In the course of time secretions are formed upon the inner surface of the glass and render the level unfit for use. It has been ascertained by experiment that these are due to the action of the water, traces of which are usually found in the ether with which the levels are filled. Since it is exceedingly difficult to fill a level with ether which is entirely free from water a kind of glass which is but little affected by the action of water should be chosen in the construction of the level. A method for testing this quality of the glass by means of a color re-action has been devised and may easily be applied even by an unskilled person. Let a glass tube be filled with a solution of water and ether containing also a little eosin. After the solution has stood for some time in the tube the glass will assume a ruddy tint and the greater the action of the water upon the glass the more pronounced will

* Die Thatigkeit der Physikalisch—Technischen Reichsanstalt bis Ende 1890. Loewenherz.

this tint become. By the decomposition of the glass a certain quantity of alkali is liberated and is transformed by the eosin into a colored salt.

The conclusion of the whole matter reached by the author of the report is, that: A level tube before it is filled should always be subjected to a special treatment consisting in removing from the ground glass surface their alkaline components by means of an acid. GEO. C. COMSTOCK.

Double Star S 503.—Amateur observers can hardly find a more interesting and striking example of proper motion than S 503, a double star first observed by South in 1825. It is an easy object, the stars being about the seventh and eighth magnitudes. For the past few years the brighter star has been passing by the fainter at a rapid rate. Their nearest approach occurred in 1886. After South's measurement in 1825, it was not observed again until 1873 when Dembowski measured it and found the position so unlike that of South that he at first supposed it to be a new double. Since that time it has been followed by the leading double star observers. Its rapid motion has led me to look up the earlier measurements, and these I will give below, as the sources may not be available to all your readers. I find most of them in Mr. Burnham's Contribution to the Memoirs of the Royal Astronomical Society, 1883, and the more recent in the Astronomische Nachrichten. I subjoin my own values for '90 and '91. S 503, $5^h\ 49^m + 13°\ 56'$.

1825 07	134.1°	39.94″	S.
1873.93	120.1	8.08	De.
75.21	118.6	7.07	De.
75.88	117.5	6.72	De.
81.18	99.3	3.58	B.
82.16	92.4	3.28	B.
83.11	82.6	2.90	B.
86.19	40.0	2.27	Ho.
87.04	30.4	2.83	Tarrant.
88.17	19.7	3.29	Tarrant.
89.11	8.6	3.36	B.
90.14	0.8	4.41	
91.21	353.2	4.60	

M. W. WHITNEY.

The Perseid Radiant. The approach of the season for observing the Perseid meteors leads me to express a hope (through the medium of your columns) that these meteors will be closely observed in America during the present year. The chief points to which observation should be direc ed (at least as regards the rival theories of Mr. Denning and myself) are as follow:

1. Do meteors come from the principal radiant situated at about 44° R. A. 56 N. Decl. before and after the first fortnight in August?

2. Mr. Denning's first five positions of his shifting radiant being 3° R. A., 49° N. Decl. on July 8; 11° R. A., 48° N. Decl. on July 13; 19° R. A., 51° N. Decl. on July 19; 25° R. A., 52° N. Decl. on July 22 and 23 and 29° R. A., 54° N. Decl. on July 27; two questions arise: (*a*) Do meteors come from these five points at other dates than those given above? And (*b*) do meteors come from intermediate positions at intermediate dates?

Dublin, May 9. W. H. S. MONCK.

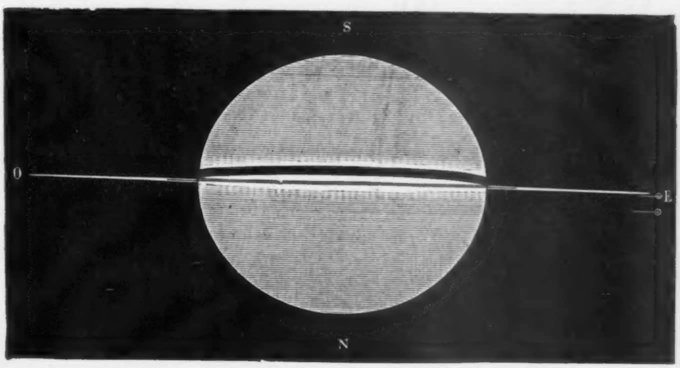
Brooklyn Institute.—At the annual meeting of the Astronomical Department of the Brooklyn Institute on May 11 officers were elected as follows: President, Garrett P. Serviss; Vice President, Arthur C. Terry; Secretary, W. F. Sebert; Treasurer and Librarian, B. G. Way.

The annual reports showed the department to be in a flourishing condition. Besides its regular meetings it has given during the past year a series of popular lectures which have been very largely attended. During the coming year an effort is to be made to extend the activity and usefulness of the department both in its scientific work and in its relations to the public at large.

Catalogue of the Crawford Library of the Royal Observatory, Edinburgh, Scotland.—This is a royal octavo volume of 497 pages. It contains the titles of the various books, pamphlets and manuscripts collected in the Library of the Dunecht Observatory it the years 1872 to 1888, the whole of which were presented to the Edinburgh Royal Observatory by James Ludovic, Earl of Crawford, in the Autumn of 1888.

The Catalogue is an alphabetical one, arranged chiefly according to the authors' names which appear in clear heavy-faced type; then follow the title of the book, and sub-titles when necessary to give a more definite idea of the book, or to distinguish it from other editions by the same author, the tomes, parts or volumes; the size, place of publication and other important characteristics that a complete catalogue might be expected to show. For more ready reference for some works, subject-headings have been introduced. In such cases if the author's name is given the book is catalogued twice. These subject-headings may be illustrated by the following examples: "Academies," "Astronomical Curiosities," "Aurora Borealis," "Bibliography," "Calendars," "Comets" and "Dictionaries." This catalogue was completed and has been distributed by Ralph Copeland the director of the Royal Observatory at Edinburgh, and is certainly a very useful one for students of astronomy and kindred sciences.

Erratum. We are very sorry to notice too late for correction that Fig. 7, page 172, was repeated in the place of Fig. 9 which is given below and is meant in explanation on page 179.



BOOK NOTICES.

THE PACIFIC STATES; THE WORKS OF HUBERT HOWE BANCROFT. In thirty-nine volumes, San Francisco: The History Company.

The annals of literature cannot furnish a parallel to the remarkable achievement of Mr. Hubert Howe Bancroft. We have here an imposing series of massive volumes, aggregating some thirty thousand pages, all published within nine years; and this enormous product is not, like poetry or fiction, evolved from the mind of the writer, but it is the product of the most laborious research through a vast mass of raw material, conducted with the most painstaking care. The whole Pacific slope has been carefully treated, from the five volumes on the Native Races down to the year 1890.

It is not strange that many devotees of literature have felt and expressed a mild contempt for a work planned on so vast a scale and so rapidly executed. The man who puts ten years of conscientious labor on a volume or two, can hardly look with complacency upon another who can put forth forty volumes in the same time, and feels that quality must have been sacrificed to quantity. In a certain sense this has been done. As Mr. Bancroft tells us in the volume on "Literary Industries," the material has been worked up, and in large part the narratives written, by a corps of assistants, and his own work has been that of editor, though he has himself worked out some more critical portions of the history. In no other way could the prodigious work have been accomplished. It is not for its literary qualities that the work is valuable. It is hardly likely that the enthusiastic hope of the author will be realized, that the work will be a household treasure in the homes of the western slope, and the boys and girls will devour these volumes as they now do their magazines. It is as a storehouse of material and an index of original sources that it is of greatest value; as such it is invaluable.

By no means do we deny to these volumes an interest to the general reader. If they will not take a place beside the works of Gibbon and Macaulay in general literature there are passages and even whole volumes full of fascination. But the very size of the work is against its general acceptance. The reader of to-day is too lazy, and he finds too much of literary sweet-meats carefully broken to his taste, to make it at all likely that he will even attempt to work his way through such a mass as this. But to the serious-minded reader of American history, and to the special student this work is of great value and interest, and it certainly ought to be in every large public library and in every college library.

The story of the growth of this great enterprise as told by Mr. Bancroft is one to stimulate the reader through the writer's own enthusiasm. The transformation of the youthful bookseller among the rough surroundings of early California into the enthusiastic collector in every part of the world where material on the Pacific states might exist, and his further transformation into the author-editor of the greatest literary enterprise of the day is certainly unique. The great collection of historical material made in preparation for the writing of these histories, is an honor to the

man, and to the region that contains it. It was indeed a noble enthusiasm that took so capable a business man from his great business, and drove him to spend years of time and hundreds of thousands of dollars, to preserve and set forth the history of his adopted state, and the resulting work is of great value not only to the region treated of, but to the whole world.

While the literary execution of the history is not marked by great rhetorical excellence, it is not slovenly nor inadequate. The temper of mind is judicial, and the facts are set forth, so far as we can judge, without fear or favor. It is a history of the people and preserves for all time the picture of an unique period in the world's history, in such detail as to make it vivid and lasting.

We hope to follow this general article with others on some of the separate parts of Mr. Bancroft's work.

Telescopic Work for Starlight Evenings, by William F. Denning, F. R. A. S., Messrs. Taylor & Francis, Red Lion Court, Fleet Street, London, England. 1891, pp. 361.

This important book was written by Mr. Denning, at the suggestion of friends who became interested in the articles which he prepared on "Telescopes and Telescopic Work" for the *Journal* of the Liverpool Astronomical Society, in 1887-8; on "Large and Small Telescopes," "Planetary Observations," and kindred topics that he has furnished from time to time to the *Observatory* and other scientific serials. These articles have been rewritten and so much extended to include new matter that they are virtually new, and the book itself has the force of an entirely new production. A glance at its table of contents will interest any reader of astronomy who knows anything of the author's ability as a practical astronomer and a ready writer on general astronomical themes. The first chapter deals with the Telescope, its invention and the developement of its powers. The early history of attempts at telescope making, and a reference to the state of scientific knowledge in the seventeenth century is a fitting introduction, for a brief and concise statement of the elemental principles of the telescope, which began to be known in the study of the optical powers of glass and some other transparent substances. The different forms of the reflecting telescope are illustrated and commented upon, accompanied by good pictures of Sir Isaac Newton and the Royal Observatory at Greenwich in Flamsteed's time. This chapter closes with a statement concerning the efficiency of the refracting telescope as an instrument for astronomical work which the author is inclined to rate a little higher than American Astronomers generally do, and, we suppose, rightly, because from long use he knows exactly what that kind of telescope can do. He also speaks of the large telescopes of the world, giving items of cost, kind of work they are doing, and something of the men who handle them. We notice one slip of the pen on page 18, where it is said that the noble instrument of the Lick Observatory at Mt. Hamilton, California, "is due to the munificence of one individual, the late James Lick, of Chicago," etc. Mr. Lick was a resident of California and not of Chicago.

The second chapter is devoted to the relative merits of large and small telescopes, and it is a timely article on a theme that interests astronomers

in all branches of work. The third deals more directly with telescopes and their accessories, and brings us a little nearer to the author's work as a painstaking observer. In this chapter he speaks of the choice of a telescope in the outset, compares refractors and reflectors, noting points of strength in each quite fairly, sets before the reader what the observer's aims should be, tells him how to test a telescope and its mounting, speaks of eye-pieces and how to use their varied powers after learning how to measure them, and a large number of other details about the working of a telescope that every obsevrer ought to know. Then follow chapters upon these themes: Notes on Telescopic Work; Sun; Moon; Mercury; Venus; Mars; Planetoids: Jupiter; Saturn; Uranus and Neptune; Meteors and Meteoric Observations; The Stars, Nebulæ, and Clusters of Stars; and Notes and Additions and Index.

This book is fully illustrated, well printed on strong white paper, and is a credit to the well-known publishing House of Messrs. Taylor & Francis.

Optical Projection. A Treatise on the Lantern, in Exhibition and Scientific Demonstration. By Lewis Wright, Author Light; A Course of Experimental Optics, with 232 Illustrations. Publishers, Messrs. Longmans, Green & Co., London, and New York, 15 East Sixteenth street. 1891. All rights reserved. pp. 426. Price not given.

The author's account of the occasion of preparing the work before us is itself a sketch of work with commendable scientific zeal and persistence. After nearly forty years of experimental study, the results are gathered up and presented in a compact, readable way, with ample illustration which serves excellently to define the meaning of simple language in a book of this kind.

The author first considers the art of projection in the simplest way, and this necessarily involves a description of the principal parts of a lantern, the most important one of which is the radiant. The things needful for an effective radiant are stated, and then the best lights are compared, and the strong points of each emphasized. This study includes lanterns and their manipulation, screens and lantern accessories, slides, carriers and effects. Another prominent feature of the book is to show how to use the lantern for scientific demonstration. This includes a description of the projection microscope, demonstrations of apparatus in mechanical and molecular physics, and physiological demonstration by the aid of the microscope. Then, naturally follow themes for illustration from chemistry, sound, light, and its properties, the spectrum, interference of light, lantern polarizing apparatus, polarized light, heat, magnetism and electricity, and scientific diagrams of all kinds. From this broad range of topic, it will at once be seen, that almost every thing connected with the work of projection, that a student or operator wants to know, is touched upon, if not considered in a complete and exhaustive way. This is not a book of theories only, but it is intended to be a practical guide for those who wish to gain exact knowledge about projections, and instruments for such work, in such way as to be able to use their knowledge if occasion presents itself. We have found the perusal of this book very valuable. It has decided some important questions about means to an end which will save money, and therefore we commend its perusal to those interested in any line of work requiring lantern illustrations. American purchasers can procure this book from the publishers in New York.

A Great Railway.

The Chicago Millwaukee & St. Paul Railway Company now operates over sixty-one hundred miles of thoroughly equipped road in Illinois, Wisconsin, Northern Michigan, Minnesota, Iowa, Missouri, South and North Dakota. Each recurring year its lines are extended in all directions to meet the necessities of the rapidly populating sections of country west, northwest, and southwest, of Chicago, and to furnish a market for the products of the greatest agricultural and stock raising districts in the world. In Illinois it operates 317 miles of track; in Wisconsin 1,636 miles; in Northern Michi-96 miles; in Iowa 1,551 miles; in Minnesota 1,115 miles, in South Dakota 1,092 miles; in North Dakota 118 miles; in Missouri 140 miles, and the end is not yet. It has terminals in such large cities as Chicago, Milwaukee, La Crosse, St. Paul, Minneapolis, Fargo, Sioux City, Council Bluffs, Omaha, and Kansas City and St. Joseph, Mo., and along its lines are hundreds of large and small thriving cities, towns and villages. Manufacturing interests are cultivated, and all branches of trade find encouragement. The Railway Company has a just appreciation of the value of its patrons, and its magnificent earnings are the result of the good business tact which characterizes the management of its affairs.

The popularity of the line is attested by the fact that notwithstanding the strongest kind of competition of old and new lines, the Chicago, Milwaukee & St. Paul Railway continues to carry the greater proportion of all the business between Chicago, Milwaukee, St. Paul and Minneapolis. It is the best patronized route between Chicago, Council Bluffs and Omaha to and from all points in Wisconsin, Minnesota, Dakota and Iowa, and its Kansas City and St. Joseph line has taken equal rank with the o der lines leading to and from the Southwest.

On all its through lines of travel the Chicago, Milwaukee & St. Paul Railway runs the most perfectly equipped trains of Sleeping, Parlor and Dining Cars and Coaches. The through trains on all its lines are systematically heated by steam. No effort is spared to furnish the best accommodations for the least money, and, in addition, patrons of the road are sure of courteous treatment from its employes.